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ELECTROMECHANICAL

components & systems | DESIGN

AUGUST 1959

in this issue

components digest 8

electromechanical switches

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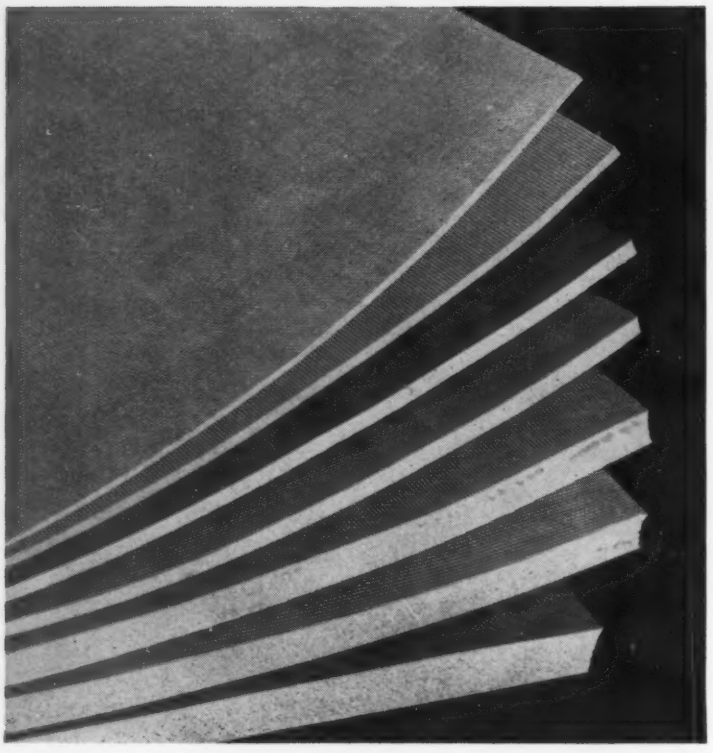

Silicone Sponge Rubber

remains flexible at extreme temperatures
—100° F to 500° F

COHRlastic R-10470 silicone sponge rubber has a dense, uniform, non-absorbing closed cell structure, highly suitable for soft gasketing, vibration dampening, fairing strips, seals, pads, bumpers, dynamic cushions and other applications where resiliency at extreme temperatures is required. It has superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening and good chemical resistance — non-sticking, odorless, non-corrosive.

COHRlastic R-10470 can be bonded to metals, plastics, fabrics or silicone rubber. Sheets 24″ x 24″ and in thicknesses 1/16″ through 1/2″ are available from stock. Larger sizes up to 30″ x 30″ and special molded and extruded shapes are made to order. CHR silicone sponge rubber is sold nationally through distributors.

FREE SAMPLES and folder — write, phone or use inquiry service.

COHRlastic R-10470
Silicone Sponge Rubber

SPECIFICATIONS:
COHRlastic R-10470 meets many specifications. Some are listed below:
AMS 3195
AMS 3196
MIL-R-6130A type 2
Boeing BMS 1-23
Martin MC1 4546
Martin MB 6130
Bendix ES 0709
Douglas DMS 1597
Lockheed LAC 1-924

PROPERTIES	Range of typical properties COHRlastic R-10470	Typical accepted standards
Tensile	50-130 psi	40 psi, min.
Elongation	175-225%	125% min.
Water absorption (Immersion 24 hrs. @ 75°F.)	3-6%	10% max.
Density, lbs./cu. in.	.020-.030 (firm)	.030 max.
	.013-.018 (medium)	.020 max.
Low temperature brittleness (5 hrs. @ −100°F., bend flat)	No cracking	No cracking
Compression deflection (compressed to 75% of original thickness)		
Room temperature		
Type firm	12-18 psi range[1]	12 min.-20 max. psi
Type medium	8-14 psi range[1]	6 min.-14 max. psi
−65°F. pct. difference	−10% to +15%[1]	
212°F. pct. difference	+5% to +10%[1]	
Compression set (compressed to 50% of original thickness)		
22 hrs. @ 70°F	0-5% (firm)[1]	10% max.
	5-30% (medium)[1]	40% max.
22 hrs. @ −65°F	0-5% (firm)[1]	10% max.
	5-30% (medium)[1]	40% max.
22 hrs. @ 212°F	10-25% (firm)[1]	30% max.
	20-50% (medium)[1]	60% max.

1 ASTM D 1056-56T

CHR products include:
COHRlastic Aircraft Products — *Airframe and engine seals, firewall seals, coated fabrics and ducts*
COHRlastic Silicone Rubber Products — *Silicone rubber moldings and extrusions, silicone rubber sheets, silicone sponge rubber*
Temp-R-Tapes — *Pressure sensitive, thermal curing Teflon and silicone tapes*
Allied Products — *COHRlastic silicone cements and conductive gasketing*

Leader In Fabrication of Silicone Rubber

CONNECTICUT HARD RUBBER COMPANY

Main Office: New Haven 9, Connecticut

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ELECTROMECHANICAL

components & systems **DESIGN**

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ELECTROMECHANICAL DESIGN

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The Sourcebook of Design Ideas in Applied Electromechanics

VOL. 3, NO. 8

AUGUST 1959

ELECTROMECHANICAL components & systems DESIGN

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Circulation for August: over 28,000

BPA

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more answers to switching problems

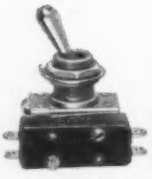
- quality engineered designed to meet human factors
- over 60,000 switch and actuator variations available
- adaptations can be made to fit your requirements

single pole

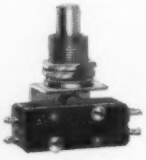
actual size

S series
SPDT

A2-2/S2-4 roller lever

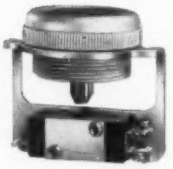


A3-24/S1-4 momentary



A4-1/S1-4

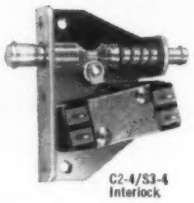
A4-25/S3-4 removable plastic button



A4-102/S2-3 1" colored button

A5-1/S2-4 roller leaf

A5-7/S2-4



C2-4/S3-4 interlock

L.W.H. 1¼" x ½" x ½"
Elec. 10 amps @ 125/250 V.A.C.
Rating: 10 amps @ 30 V.D.C.
Operating Force 9 to 15 oz.
Amb. Temp. −100° to +375° F.
Termination: S1—end solder,
S2—screw
S3—side solder
S5—U-bent
S6—long screw
For switches conforming to Military and U.L. approval, write for details.
Reset types also available.

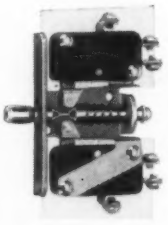
in stock? WE HAVE THEM...

single pole

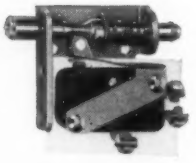
actual size

F series
SPDT

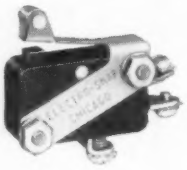
A5-49/F2-3 leaf



C2-6/F2-3 interlock, DP



C2-10/F2-3 interlock, SP

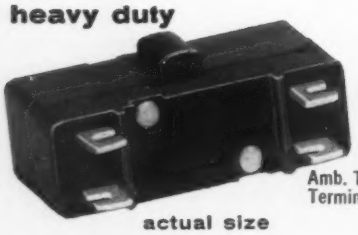


A5-47/F2-3 roller leaf

A5-56/F2-3 extension leaf

L.W.H. 1-3/32" x 13/32" x ⅝"
Elec. 10 amps @ 125/250 V.A.C.
Rating: 60 cycles
10 amps Res. @ 28 V.D.C.
6 amps Ind. @ 28 V.D.C.
Operating Force 7 to 12 oz.
Amb. Temp. −100° to +350° F.
Termination: F1-solder, F2-screw
May be banked with unlimited units per row. For switches conforming to Military and U.L. approval, write for details.

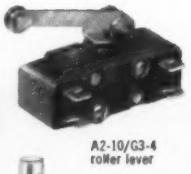
heavy duty



actual size

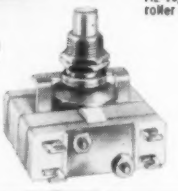
G series
SPDT, 2 CKT.

A3-40/G3-4 maintained

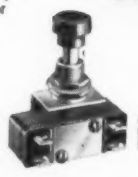


A2-10/G3-4 roller lever

A4-50/G3-4



A4-51/G3-8 DPDT



A4-71/G3-4 removable plastic button

L.W.H. 1¾" x 43/64" x 35/64"
Elec. 40 amps @
Rating: 125/250 V.A.C.
40 amps Res. @ 30 V.D.C.
30 amps Ind. @ 30 V.D.C.
Operating Force 45 oz.
Amb. Temp. −100° to +300° F.
Termination: G3—side solder
G4—top and bottom screws
Reset models also available. For switches requiring Military and U.L. approval, write for details.

40 amps? YES...

Need a special switch?

Often standard switches can be modified to do the job. If a special switch is required, Electrosnap engineering can create new switches in any quantity to your specifications. Send us your problem ...our answer can save you time and money.

Call Or Write For Specific Details On Any Switch Type

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Telephone: VAn Buren 6-3100, TWX No. CG-1400

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components & systems **DESIGN**

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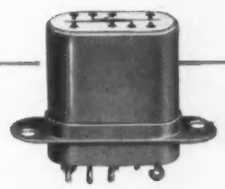
small . . . but ***mighty***

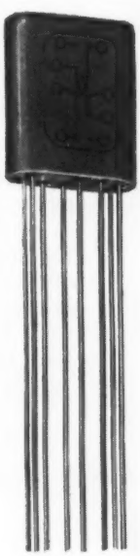
COMAR'S SUB-MINIATURE TYPE SM



Less than an inch long — Weighs less than ½ oz.

big relay performance
in crystal can size

A high precision, efficient sub-miniature relay. Constructed to withstand severe vibration, heavy shock and temperature extremes. For control systems, missiles, computers, aircraft and similar applications requiring miniature size and dependable performance.



Nominal Coil Voltage: 26.5 Volts D.C.
Maximum Pull-In Voltage: 18 Volts D.C.
Maximum Drop-Out Voltage: 14 Volts D.C.
Coil Resistance: Approximately 570 Ohms.
Contact Arrangement: 2 P. D. T.
Contact Rating: 2 Amps. @ 28 V. D. C. Resistive (max.).
Maximum Operate Time (N.O. Contacts): 4 Milliseconds.
Maximum Release Time (N.C. Contacts): 3 Milliseconds.
Maximum Contact Bounce: 1 Millisecond.
Dielectric Strength: 1000 V. RMS, 60 Cycles (Sea Level).
Minimum Insulation Resistance: 100 Megohms.
Maximum Contact Resist: 0.05 Ohm; 0.10 Ohm (After Life).
Temperature Range: −65° to 125° C.
Operating Shock: 50 "G" for 11 Milliseconds.
Vibration: 20 "G"—5 to 2000 CPS.
Life: 100,000 Operations (Minimum).
Maximum Weight: .45 Oz.
Meets MIL-R-25018 and MIL-R-5757C specifications.

Send for Bulletin SM

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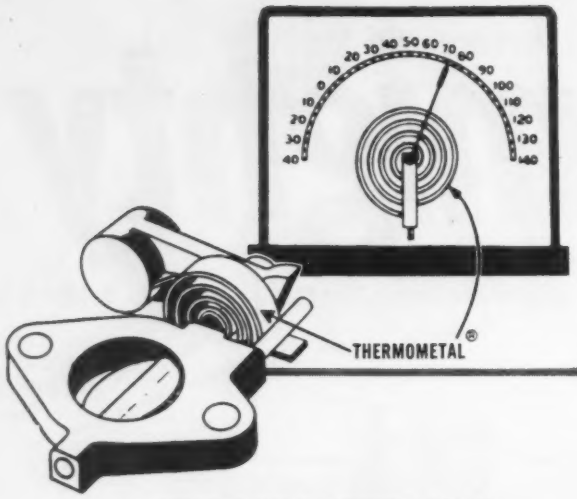
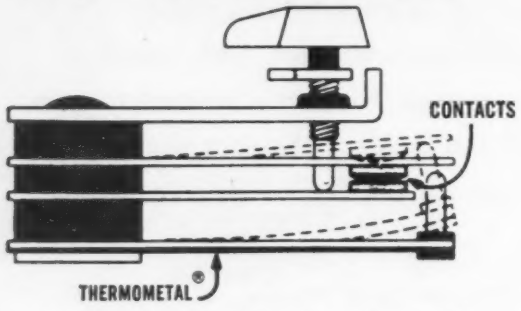


THERMOMETAL® for dependable temperature, electrical current and voltage control applications



Leading manufacturers depend upon the outstanding performance of Thermometal in electrical appliances, thermal cutouts, heating controls and many other applications involving the indication and accurate control of temperatures, electrical currents, voltages, etc. Thermometal is supplied in strip form, rolled and slit to close tolerances and tempered to specification. Thermometal elements and sub-assemblies are also supplied to specifications, with or without contacts attached. Send for literature.

H. A. WILSON DIVISION • U.S. HIGHWAY 22
UNION, N. J.

look to Amersil for all high purity fused quartz requirements.

Amersil manufactures and fabricates high purity fused quartz for ultraviolet transmission applications, laboratory ware and production equipment. These products include standard apparatus, plain tubing in many intricate fabrications, crucibles, trays, cylindrical containers and piping in a full range of sizes up to 25" in diameter. Ingots and plates are available in general commercial quality as well as in special optical grades. Amersil engineers are also prepared to assist in developing fused quartz and silica equipment for special requirements. Send for bulletin.

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HILLSIDE, N. J.

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CIRCLE 3 ON INQUIRY CARD

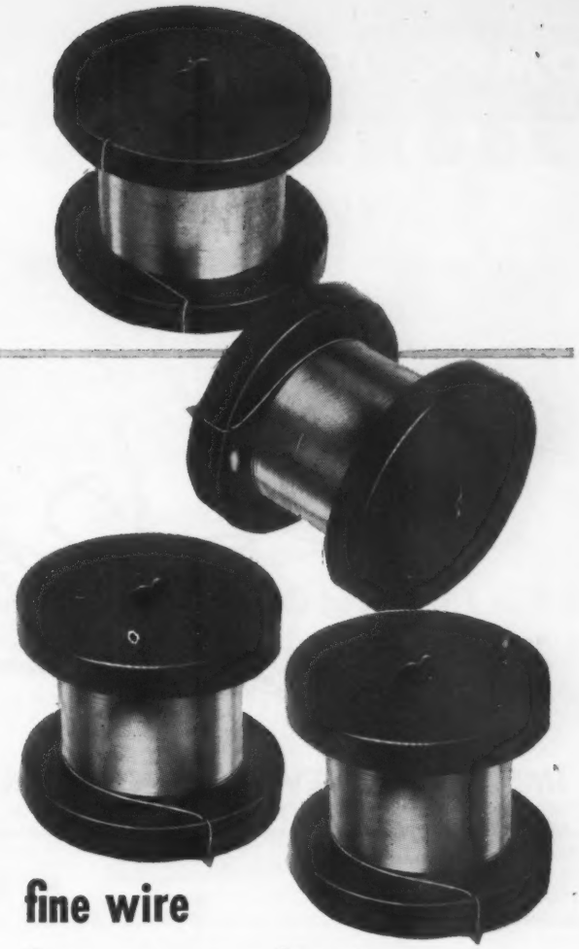
CIRCLE 4 ON INQUIRY CARD

a simplified mirror-bright silver plating process

Here is the most efficient, simple procedure to protect electrical electronic and lamp components with a mirror-bright silver finish—through a complete range from flash to heavy deposit. The procedure is easy, economical and non-critical—with little or no polishing required. Silva-Brite is a clear, water-white solution, enabling the operator to observe work as it is being plated. Uniformly good results are attained with current densities ranging from 10 to 40 amperes per square foot. Normal room temperature operation minimizes fumes and tendency toward bath decomposition. Send for descriptive data together with detailed plating procedures.

AMERICAN PLATINUM & SILVER DIVISION
231 N. J. RAILROAD AVENUE, NEWARK, N. J.

AMERICAN PLATINUM & SILVER DIVISION



fine wire for every application

Here, you will find a thoroughly dependable source for fine wire of ductile and non-ductile materials for every application. Special processes have been developed for bare drawing wire as fine as .0004". Where smaller fine wire is required, the Wollaston Process for ductile metals and the Taylor and Extrusion methods for non-ductile materials are employed. All standard fine wire requirements are stocked for prompt delivery. Full facilities are available for the production of fine wires made to your own specifications.

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CIRCLE 5 ON INQUIRY CARD

CIRCLE 6 ON INQUIRY CARD

IMPACT OF NEW COMPONENTS ON PRODUCTION TECHNIQUES

The cornucopian outpouring of new components designed for electronic and electromechanical equipment has generated severe problems in production departments. Last July at the third National Conference of the IRE PGPT devoted an entire session to the impact of new components on production techniques. Mr. Robert H. Watson of Lockheed's Missiles & Space Division in Sunnyvale, California pointed out that the majority of production problems with transistorized equipment are not basically caused by the transistors but by the essential "newness" of the modern equipment using transistors. He presented a number of case histories that emphasized his point of view.

Case Histories

Mr. Watson's first example concerned the use of transistors in an IF amplifier for piece of lightweight commercial equipment. To maintain a competitive price on the equipment, company management set an arbitrary maximum price that could be spent for the transistors. This decision called for transistors whose characteristics were not carefully controlled and led to two selection operations as part of the manufacturing routine.

First, not all the transistors of the type used would deliver sufficient amplifier gain so that a preselection for minimum beta had to be made. Second, those which would give the required gain varied so widely in internal feedback that no suitable capacitor with sufficient range could be found to neutralize the circuits.

This condition led to the two possibilities of further selecting transistors which could be neutralized within the range of a standard variable capacitor of the selection in test of the proper fixed capacitor shunted across the neutralizing capacitor to bring it within range. The latter alternative was chosen since capacitors are less expensive than transistors and also a more straightforward method of selection could be specified. Incidentally, Mr. Watson pointed out, the manufacturer does not mention in his instruction manual the necessity for either of these selection processes —and he speculated on what will happen in the field when an instrument repairman finds he has to replace a transistor.

DIFFERENTIAL DC AMPLIFIER

Mr. Watson's second example was that of a differential DC amplifier in a piece of military gear which has to operate over a wide temperature range. Here again there were two problems: that of gain requiring a preselection of the transistors for a minimum beta as in the preceding example, and a stringent requirement on the drift with temperature of the output level.

Since this DC amplifier illustrates several of the problems with the use of transistors, Mr. Watson discussed them in some detail, pointing out that transistors are manufactured in families, not in specific types, and the units in these families are then assigned by a selection process to the proper type according to their characteristics. The usual result of the grading process seems to be that the lowest performance type is obtained by the thousands, the next better type in quantities in the hundreds, the third, and if it exists, the fourth member of the family in further decreased quantities.

At the outset of the development of the differential amplifier, firm requirements for the gain of the unit could not be established, but it was determined that the use of the proper one of the two intermediate members of a family of four transistors the anticipated gain range could be covered. Further, the transistor manufacturer gave as-

surance that either of the two would be available in sufficient quantity to meet the estimated needs. By the time the actual gain requirements were determined, which was just prior to starting to manufacture the amplifiers, it was apparent that the better of the two intermediate types would be the logical choice for only about one-half the populaiton of the lower performance types would deliver the required gain.

Unfortunately, in the intervening period many other organizations had discovered the merit of this family of transistors so that even with a high priority it was impossible to obtain a sufficient quantity of the better units to meet the need. Since no acceptable substitute was available, a selection operation had to be included in the manufacturing sequence to sort out those of the lower performance units which were usable. This, of course, was a last minute introduction which created considerable disturbance throughout the organization.

On the other hand, Mr. Watson pointed out, the performance requirements with respect to temperature were initially recognized as a serious difficulty. It was necessary that the change in differential output over the required temperature range be held to that equivalent to applying a one-half millivolt signal to the input. The seriousness of the problem becomes apparent, Mr. Watson pointed out, by noting that the uncompensated change in the output of a single transistor of the pair is equivalent to 150 millivolt input signal. Thus the transistors must be paired so that their changes of current over the required temperature range are matched better than one part in 300.

Fotunately the transistors did not have to be matched for steady state current as well as for their change of current with temperature, but it was still a curve matching operation. Test circuits simulating the actual circuit were prepared and runs were made with batches of transistors taking point-by-point readings over the temperature range with careful temperature control. Those transistor pairs with curves which matched within specified limits were then installed in amplifier units, and temperature tests made on the units to determine if the matching was sufficiently close to enable the amplifiers to meet the requirements.

These examples, Mr. Watson made it readily apparent that the terrific number of potential headaches, not to mention the sheer mass of test equipment, specifications, and miscellaneous instructions is extreme for a relatively insignificant piece of equipment. On the other hand, his examples were fair presentations of some of the troubles one can get into when dealing with transistorized equipment. Incidentally, Mr. Watson pointed out that both of these problems took place with two considerably different manufacturers with whom there had not been any personal involvement or responsibility on his part. He made several recommendations to improve siuations of this type:

- Development engineers must realize that major factors in creating production problems are "newness" and lack of information. Wherever possible equipment should be designed to take advantage of existing practices, facilities and know how of the manufacturing organization. If it is necessary to introduce radically new designs, practices or materials, the design engineers must provide adequate information and sufficient time for the manufacturing organization to plan and prepare.
- Manufacturing and management personnel must recognize that new processes, operations, and types of parts are being and must be introduced in large numbers to meet the requirements being imposed on modern equipment. Consequently, new tools, fixtures, processing and test equipment must be acquired, installed and properly used in order to have successful production.
- The majority of production problems with transistorized

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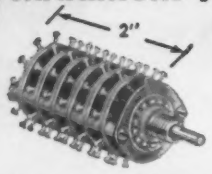

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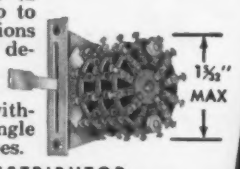

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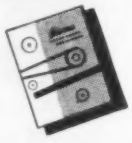

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equipment are not basically caused by the transistors but by the essential "newness" of the modern equipment being produced using transistors. Recognition of this, and of the corollary that the newness just be offset by complete information so that decisions on the production floor are not required will go a long way toward reducing production problems.

NEW COMPONENTS AND SMALL MISSILES

Edward J. Meyer, Assistant Manager of Engineering at Hughes Aircraft Co. in Tucson, Arizona, discussed the problems arising from the utilization of new components in the production of small missiles. He examined some of the common manufacturing problems that generated some of the problems during assembly-line utilization of new components: etched circuitry, soldering, coatings, shock mounting, and the inherent design limitations of components, taking into consideration "meantime to failure" for typical missile components based on "actual failure" by performance degradation and sudden failure sometimes classified as "catastraphic failure".

Here are some of the examples he used to illustrate his points.

Electronic Chassis: An investigation of the rejection of certain electronic chassis indicated that the heater-to-cathode leakage was beyond chassis specification. A portion of the chassis circuit utilized a heater-to-cathode bias which was not compatible with the bias used in the tube manufacturers' aging cycle. Studies indicated that the stability of a steering voltage, which is related to the heater-to-cathode leakage, could be improved by pre-aging the whole chassis prior to the initiation of the final unit test in production. First, preselecting tubes for low heater to cathode leakage under the chassis bias conditions, then, aging the chassis for one hour prior to chassis tests, stabilizers heater to cathode leakage and eliminates tubes which would fail later for this condition. Although certain circuit modifications could be made, these modifications were not economically feasible due to test equipment, tooling, and manufacturing planning costs. This was an illustration wherein neither the design nor the component was altered but manufacturing techniques were evolved which resulted in the lowest cost resolution.

Power Supplies: One of the electrical power supplies exhibited a case of the effect of internal heat generation. Experience with the reserve primary battery used in initial production of a particular missile showed that it was subject to malfunctions under some conditions because of burning of the electrolyte bladder during heating. The battery was modified by adding a heat diffuser and improved heating controls which corrected the difficulty. Here redesign was mandatory to insure proper function of the unit due to the fact that there was no known material which could be substituted for the current bladder material in order to provide adequate temperature resistance.

In another case the electrical power supply had a 15-watt resistor that was overheating due to space limitation and poor air circulation. Heat caused the terminal solder joint to melt resulting in intermittent output voltages and loose solder balls which could cause shorts. Addition of a staked terminal on the connecting wire and a mechanical nut and bolt joint at the resistor terminal provided an effective heat sink allowing the resistor to remain within the specified temperature limits. The mechanical joint also eliminated the possibility of molten solder in case normal operating conditions were exceeded. The mechanical joint solution was selected because it resulted in lower costs compared to redesigning the electrical power supply.

Servo Stability: A range tract servo loop exhibited a change in stability beyond specification limits with a change in

temperature. Approximately seven tubes and 100 other components were involved. The number of combinations of changes of parameters is great because of the large number of components and because the component heating is not uniformed. Manufacturing experience indicated a significant difference existing between tubes from different manufacturers. Tubes from one particular vendor were being used to reduce the failure rate for economic reasons. Determination of the specific component and or tubes characteristic causing the lack of stability has not as yet been completely resolved.

Capacitors: An elusive intermittent capacitor problem occurred with certain types of capacitors from one particular vendor. The difficulty was found to be an inserted tab capacitor which was being furnished, when actually the specification called for an extended foil capacitor. In this case the inserted tab capacitors were replaced by the manufacturer when he realized his error. In this instance, once again, because of economic considerations, the burden of resolution was placed on the component manufacturer.

Precision Resistors: A precision resistor was employed where the resistance material was sprayed on a ceramic base. The resistors were checked in receiving inspection to a close tolerance. Some of the chassis using this resistor were failing because of a change in the resistance of the component. It was discovered that when the leads were being clipped to a length in an automatic machine, the resistor was lightly clamped between a pair of fingers. Slight pressure of the fingers was causing a permanent strain in the resistance material. The automatic equipment was modified at a nominal cost rather than attempt a change MIL-R-10509 specifications, or develop a new resistor which would require several hundred drawing changes plus the costs of establishing a new MIL specification and development programs at one or more vendors.

Tube Problems: A chassis was experiencing a 50% rejection rate because of failure of two blocking oscillators. An investigation revealed that the difficulty was caused by 6111 tubes having insufficient pulse emission for the design applications. Specification MIL-E-1 requires 300 milliamperes minimum pulse emission. One of the blocking oscillators required 400 milliamperes minimum of pulse emission for satisfactory operation. It was possible to correct the operation of the oscillator, which required 400 milliamperes pulse emission, by providing for monostable operation, i.e., making a circuit change. Operation of the other oscillator is still not satisfactory; however, it is expected that a new tube with higher pulse emission characteristics will be able to solve the problem or tubes may continue to be selected. In this case, the cost of the tube selection and 100% pulse emission testing in the plant must be weighed against the cost of having a new tube developed, its incorporation in the product, and the intangible but important factors of product reliability. Unfortunately, a new tube type with higher pulse emission characteristics may represent a trade-off on other desirable tube parameters. Accordingly, it is possible that introducing a new tube into the product may merely shift our problems from one area to a new undefined area. Obviously, a rather exhaustive test program is in order, the cost of which must also be considered.

In the situation described above, Mr. Meyer illustrates the importance of considering all the parameters of a component and the statistical variation of each parameter, and the analytically, or preferably, experimentally determining the effect of these variations on the system performance. This principle is not new; however, he felt that the lack of application of this one rule is the cause of most tube problems encountered in a production manufacturing organization. Too often the development engineer will obtain a workable circuit with selected tubes or tubes from his favorite manufacturer, and then release the circuit to

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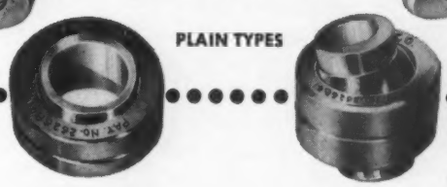

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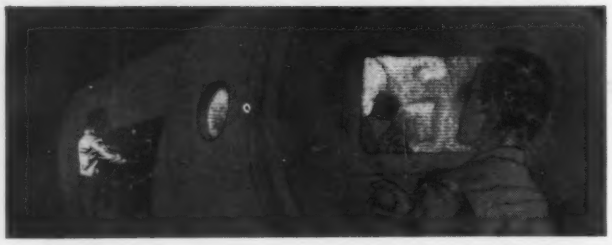

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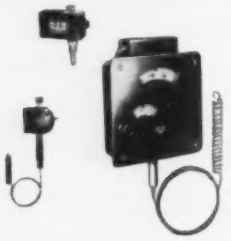

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quantity production where standard run-of-the-mill tubes will be used.

In the situation described above, Mr. Meyer illustrates RF pentode as a regulator control tube. This tube several years ago had an average replacement rate of approximately 20%. At times the situation was so bad that it was necessary to try at least two tubes per socket before the chassis would pass inspection. An improved tube, Type 6788, was developed by a vendor. This tube had the necessary low noise and high shock and vibration resistance characteristics required for this application. The rejection rate went down to 1% or less and the problem was considered to be solved. The cost of the new tube is now about the same as the 6205 tube—a dramatic case where an improved tube solved a serious quality and cost problem.

Another of Mr. Myers' tube problems involved a 60 megacycle amplifier with a 6205 pentode. A strong echo return from the target caused a large negative AGC voltage to be applied to the tube grid which drove the tube beyond the cut-off point. As a result, the automatic gain control failed and the missile would not guide. The problem was solved by placing the tube with a 6206 pentode with remote cut-off characteristics. The original trouble was clearly caused by a misapplication of the 6205 tube.

In this case Mr. Meyer pointed out that the course of action was relatively simple since the proper component was available. Had adequate coordination been effected during the R&D stage between the designer and the application engineer, this problem would never have become a serious production difficulty.

Mr. Meyer summarized his point with the fact that at times a new component must be introduced into a system irrespective of the cost in order to achieve certain tactical objectives. More often the cost of introducing a new component must be considered. In making such estimates, the manufacturing engineers should be consulted, since the development engineer may underestimate the cost of introducing a new component. The development engineer is apt to see the change as simply changing the location of several wires. The introduction of an apparently simple change will cause alternations in shop planning, tool drawings, tool changes, changes in test instructions, perhaps test equipment changes, changes in maintenance manuals, maintenance procedures, etc.

The applications engineer, he said, frequently is confronted with two alternates in achieving a given result: first, he may accept certain limitations of components and then try to devise a circuit that will still achieve the required objective, or sencondly, he may develop a new component without the previous restrictions which will then make the circuit designing problem easy. An example of this situation was mentioned above regarding the 6111 tubes with insufficient pulse emission. In one instance it was feasible to design around the limitation by providing for monostable operation. In the other case, it may be necessary to develop a new tube.

Mr. Meyer does not believe that high reliability in a complex system just happens. It is the result of careful planning and engineering. The extensive and complex tests required to determine the effect of the reliability of each component of a complex system requires a staff of first rate engineers and extensive environmental test equipment. The component manufacturers can expand the market for their products and greatly increase the probability of use of their products if they will make information available to the application engineers. A component manufacturer who knows what his products will do under many types of adverse environments is in a preferred position.

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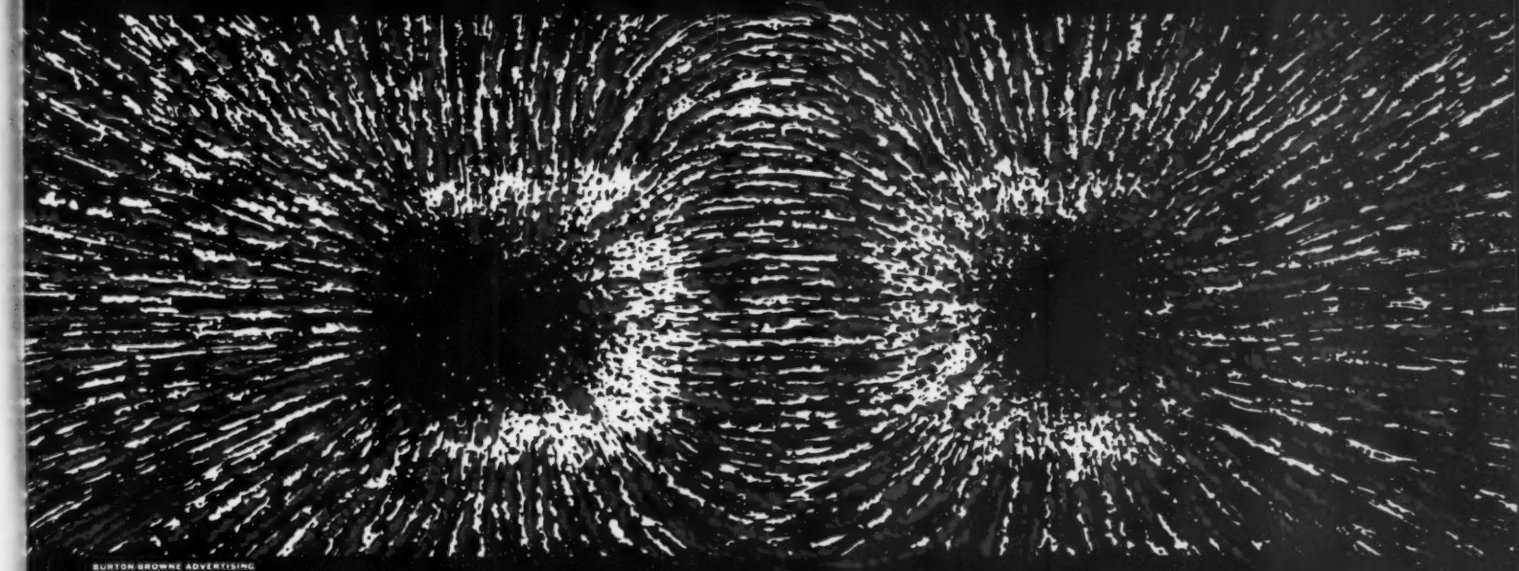

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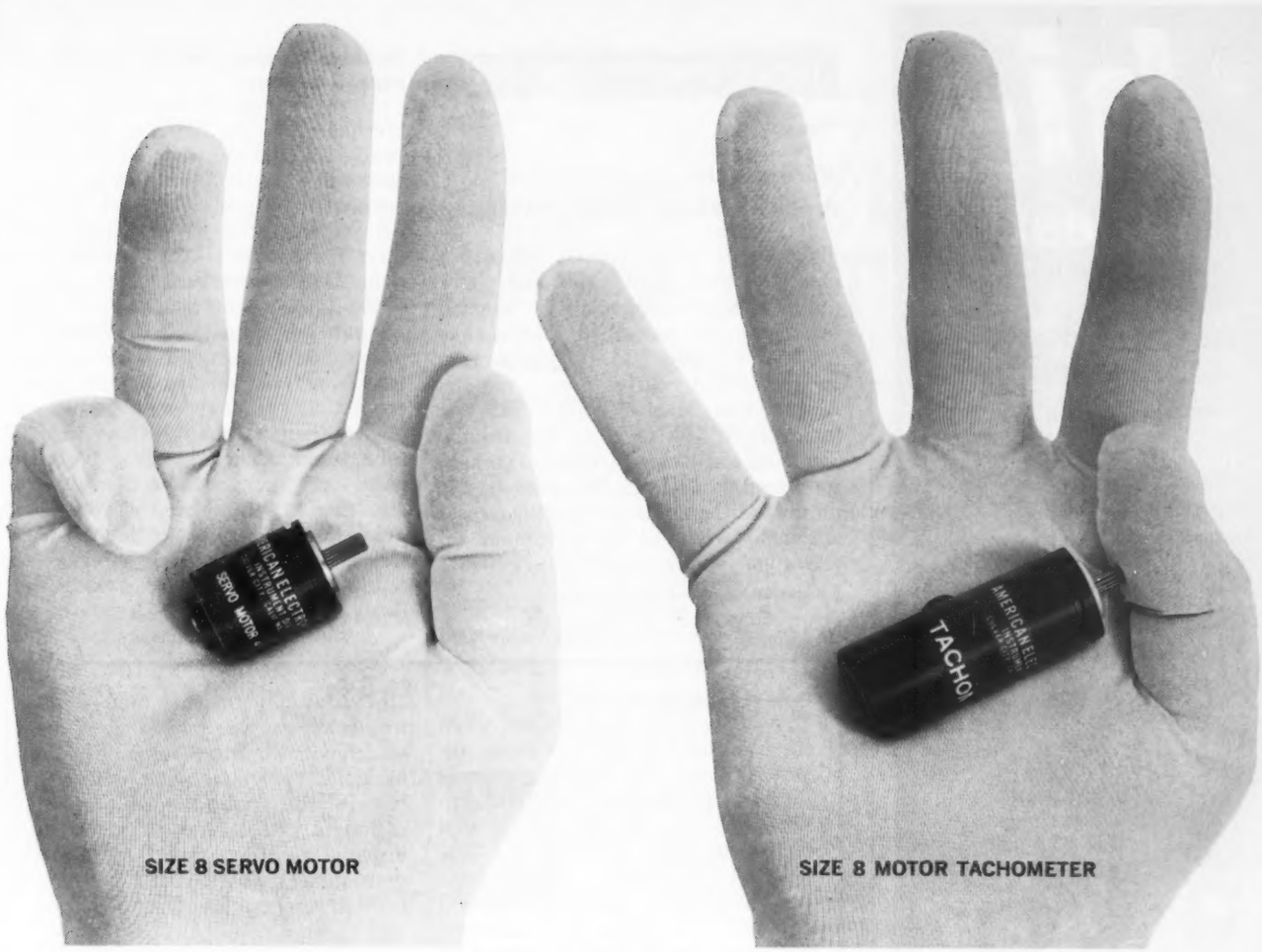

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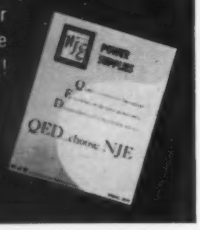

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Soviet Science Briefs

"Soviet Science Briefs" are taken from translated articles—some digested, some full-length—appearing in two periodicals, Scientific Information Report and Information on Soviet Bloc International Geophysical Cooperation 1959 IGYex) published by the Office of Technical Services, U.S. Dept. of Commerce. SIR is a semi-monthly review of current scientific and technological advances in the Soviet Union, Eastern Europe and Red China prepared from continuing literature surveys by C.I.A. ($28.00 a year, $2.75 a single copy). *Information on Soviet Bloc International Geophysical Coeration—1959* (IGYex) is a weekly account of Soviet Bloc activities under IGY-extended. ($12.00 a year).

Rocket-propelled tunnel digger is used in Russia to lay underground canals and pipes. Using liquid fuel and compressed air, a pulverizing device in the front of the digger spouts flame and blasts a path for the rocket, leaving a cylindrical tunnel behind.

Electrochemical desalting of sea water is reported to cut time and cost of providing ships with fresh water. Membranes or diaphragms of ion-exchange resins separate brine from water. Principal parts are of "viniplast, polychlorovinyl plastic, and chemically resistant rubber." Further applications are possible.

Criticism of "lagging" development of new polymers charges that despite new training programs, new laboratories and new research plans, "the institutes transfer their effort too slowly to the furthering of research on such important subjects as inorganic polymers, the scientific basis of the application of polymer materials, and natural polymers." It urges a speed-up, especially in the development of polymers resistant to high temperature, light radiation and chemicals.

Radioactive tobacco smoke causes the cancer blamed on heavy cigarette smoking. Tobacco plants take in carbon-14 from the air and when tobacco is burned the radioactive element is carried along in the smoke into the lungs. "Because of its capacity to selectively concentrate carbon 14, tobacco smoke is "cancerogenic."

Yttrium shows high promise as an alloying component. 0.1 to 0.2 percent yttrium reduces grain size of many cast metals and improves strength. Yttrium also dissolves completely in cerium, interacts with aluminum, iron and copper to form eutectic mixtures, dissolves very little in alloying with chromium, titanium and zirconium, and is practically immiscible with vanadium niobium, tantalum and molybdenum.

Metals pure to 99.999 percent will be needed in increasingly larger quantities for use in rolled products for the electronics, electrical engineering, nuclear power engineering and other rapidly "expanding" Soviet industries. Especially in demand will be rolled products of tungsten, molybdenum, tantalum, zirconium, niobium and beryllium.

SILICONE RUBBER FOR WIRES

High Temperature Insulation

Since World War II interest has increased tremendously in the use of silicone rubber (polyorganosiloxane). When compounded with inorganic fillers, additives and peroxide types of catalyst agents, this once extremely weak and difficult to handle material emerged as an excellent high temperature insulation. Almost at once the U.S. Navy began to specify silicone rubber on Navy cables. With this Navy interest, great efforts were expended to improve silicone rubber to meet increasing demands for power cable, hook-up wire, apparatus lead wire, aircraft wire, ignition cable, fixture wire, heating cable and ship work cable.

American Super Temp Wires, Inc. has decided to enter this field. They will produce eight basic types:

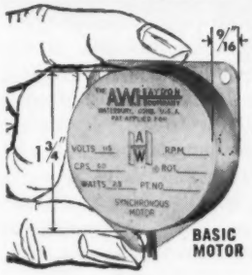
- Hook-up wire: 200C, 600 and 1000 volts service for internal wiring of electrical equipment as in MIL specs.
- Apparatus lead wire: 150C and 200C, 600 volts service for motor leads and transformer leads.
- Aircraft wire: 150C, 600 volt service, aircraft electrical wire for −55 to 150C as covered in MIL specs.
- Power cable: 125C, 600 and 5000 volt service.
- Ignition cable: −54 to 232C high tension cable for aircraft automotive and marine service, as in MIL specs.
- Electronic hook-up wire: 150C up to 30 kv service, high voltage leads for electronic equipment.
- Fixture wire: 150C and 200C, 300 and 600 volt services for lighting fixtures in high voltage units.
- Shipboard cable: 135C, 600 volt service, general purpose service on Navy ships as covered in MIL specs.

While generally specified for 200C continuous operation, silicone rubber will maintain its physical and electrical properties after a short time exposure at 315C. Special compounds have been known to maintain flexibility at −100C.

One of the most desirable characteristics of silicone rubber installation is that, when burned, it produces an ash. This ash, held in place with fiberglas braids, will continue to be an insulator. Radiation resistance lies within the range of 5×10^7 roentgens to 1×10^8 roentgens. Silicon rubber insulation shows virtually no effect to ozone and corona problems. A general summation of its characteristics: heat resistance, low temperature flexibility, ozone resistance, electrical stability, weathering resistance, aging resistance, non-conducting ash, chemical inactness, non-toxicity, solderability, thermal conductivity and radiation resistance.

Circle No. 82 on Inquiry Card

ANOTHER FIRST...



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Only 9/16 Inches Short... Only 1¾ Inches in Diameter... very compact... reduces the size of your equipment.

WHISPER-QUIET...
Strictly an electrical motor... practically noiseless... no rattling of gears or ratchets.

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¼ oz. inch at the rotor with an instantaneous start and stop... requires only 2½ watts... can replace larger motors in recorders, controls and telemetering equipment.

HIGHEST RELIABILITY...
Longer life... no one-way gears or ratchets to fail... provides millions of operations without any trouble.

Send for Special Illustrated Bulletin AWH MO-806

SPECIFICATIONS

Standard Voltage Ratings: 6, 12, 24, 115, 230 Volts
Frequency: 60 CPS Standard; 25, 50 CPS Available
Power Input: 2.5 Watts Maximum (60 CPS)

BASIC MOTOR
Weight: 4 ounces
Speed: 300 RPM
Torque: ¼ oz-in.
Length: 9/16 inch

WITH INTEGRAL GEAR TRAIN
Weight: 5 ounces
Speed: 300 RPM to 1/6 RPH
Torque: 30 oz.-in. @ 1 RPM
Length: ⅞ inch

WITH INTEGRAL GEAR TRAIN

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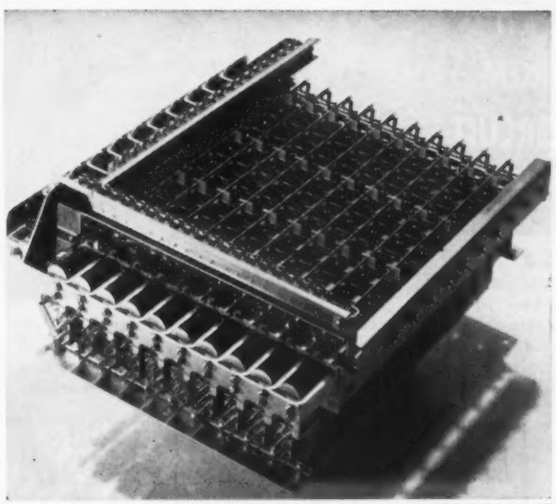
CIRCLE 16 ON INQUIRY CARD

CUNNINGHAM CROSSBAR SWITCH



• FUNCTION AND OPERATION
By means of a coordinate system of select and hold magnets operated sequentially, a mechanical operation is performed at a crosspoint. This mechanical operation in turn makes electrical connection at the crosspoint, establishing a circuit to one of 100 crosspoint terminations. Each circuit may have 1 to 6 wires (poles).

OUTSTANDING FEATURES
- Switches up to 70 mc.
- Low crosstalk
- Fast quiet operation
- Long life
- High Insulation resistance
- Plug-in connections
- Twin gold contacts
- Compact design
- Low operating power
- Applications in: Signal Distribution, Programming, Computer Systems, Radio and Television Signal Switching

SIGNAL CARRYING CHARACTERISTICS

CROSSTALK—down 55 db. at 4 mc. in a 10 x 10 switch with 75 ohm termination under the worst condition (parallel input paths connected to parallel output paths). The addition of shields in the link direction gives a 75 ohm characteristic impedance through the switch and further reduces the crosstalk.

BRIDGING CAPACITY—to ground between an input conductor connected to an output conductor in a 10 x 10 switch is 15 mnfd.

BREAKDOWN VOLTAGE—occurs at not less than 1500 VAC between switching conductors and frame and across switching contacts.

INSULATION RESISTANCE—Special materials give insulation resistance at 10,000 megohms—conductors to frame and between conductors.

CONDUCTOR RESISTANCE—through longest path in a 10 x 10 switch is 0.3 ohms.

CURRENT CARRYING CAPACITY—Contacts will carry 100 milliamps non-inductive load at 50 VDC for 20 million operations. Increasing current to 1.0 amp decreases life below 1,000,000 operations.

CONTACT BOUNCE—is less than 200 micro-seconds on make. No bounce on break.

TIMING—Switch can be set up in 15 milliseconds at normal operate voltage. Scanning speeds of 60 cps are attained with transistor drive circuits. See bulletin 58-212 for additional information.

TERMINAL TYPES—(1) A-MP Taper Tab Connectors (A-MP Series 78) may be used on all switching and coil terminals (except off-normal switch terminals).

Write for further literature to:

JAMES CUNNINGHAM, SON & CO., INC.
33 LITCHFIELD ST. ROCHESTER 8, N. Y.

CIRCLE 17 ON INQUIRY CARD

COMPONENTS DESIGN

Solenoid Hand Controlled Air Valve

A new solenoid valve that can be actuated by hand, whether the coil is energized or de-energized is ideal for all low pressure air systems (to 150 PSI) whether manual control is part of normal production set-ups or whether it is needed only on rare emergency occasions. On die-setting and clamping operations it gives manual control during the set-up stage before letting power operation take over. Electrical and operational failures in the system can be checked without the need for halting production. Barksdale Valves, Los Angeles, Cal.

Circle No. 198 on Inquiry Card

Micro-Miniature Rectifier

Match-head size rectifier capable of withstanding severe temperature change and shock in missile flight can be used in airborne computer systems with 600 volt power supplies. It will handle up to 150 milliamps at 150 degrees C. Dissipation rating is high at 600 milliwatts. Clevite Transistor Prods., Waltham, Mass.

Circle No. 208 on Inquiry Card

Solenoid Operated Snap Switch Relay

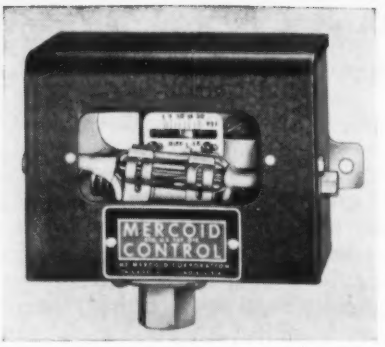
New rugged multi-pole solenoid-operated snap-switch relay, SS 101, is designed for control of circuits handling inductive loads. It is available in contact arrangements up to six pole double throw. Each contact is rated at 10 Amps, 1/3 HP, at 125 Volts ac or 5 Amps, 1/3 HP, at 250 Volts ac. Either quick connect or solder terminals are available on both switches and coil. Dimensions are 3¼″ long by 1⅞″ diameter. Warco Industries, Inc., St. Louis, Mo.

Circle No. 196 on Inquiry Card

Pot Mounting Stud Mount Adjustoroids

Pot mounting Adjustoroid for panel mounting and knob adjustment insure easy access wherever slotted controls are difficult to reach. Stud mount encapsulated Adjustoroid, designed for printed circuit use, provides greater durability in high acceleration, shock and vibration environments. Sub-miniature Adjustoroids are supplied hermetically sealed to meet MIL-E-15305A or encapsulated to fit special applications. Bulletin available. Burnell and Co., Pelham, New York.

Circle No. 189 on Inquiry Card



Pressure Control Weighs 1¾ lbs

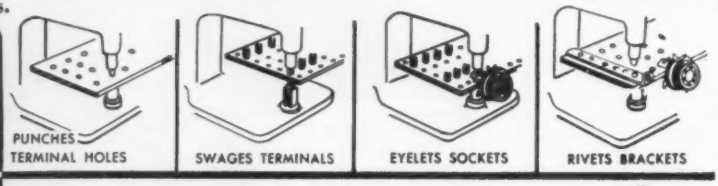
New pressure control Type AP-153 has external adjustment, repetitive trip point, visible calibrated dial with pointer, visible hermetically sealed mercury contact. Specifications: Operating range (adjustable) 1 to 20 psig. Differential (fixed) 0.5 psig. Maximum pressure 30 psig. Operating point easily set by external adjustment. Contact: Hermetically sealed mercury switch (4A. 115V., 2A. 230V.) single pole, double throw. Provides any of following operations: single pole, cut in high (close on rise); single pole, cut in low (open on rise); or single pole, double throw. Switch leads—Silicone rubber covered. The Mercoid Corp., Chicago, Illinois

Circle No. 202 on Inquiry Card

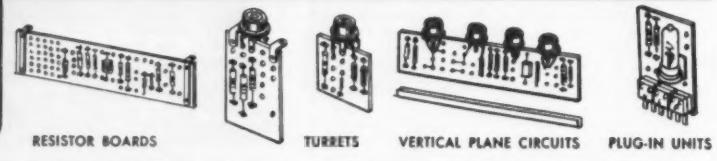
NEW $49.95 KIT MOVES YOU FROM SCHEMATIC TO CIRCUIT *FAST & RELIABLY!*

Here's an all-in-one tool for prototype and small production runs that makes it simple to organize and mount circuitry in compact, planes. It quickly swages Alden terminals, eyelets, brackets and tube sockets, and punches .101″ terminal holes in Alden XXP phenolic cards or any 1/16″ cold punch card. You can make up circuitry turrets in minutes — complete with terminals, brackets and sockets.

Does ALL these operations:



Makes ALL these parts:



SAVE $10 on kit over individual part prices. **Contains Alden Universal Staking Tool and assortment of prepunched terminal cards, terminals, tube sockets, brackets and eyelets to get started immediately. Order Kit #42 — $49.95 complete.**

ALDEN PRODUCTS CO., 8138 N. Main Street, Brockton, Mass.

CIRCLE 18 ON INQUIRY CARD

Miniature Transducer Is Oil-Damped

Miniature pressure transducer is oil-damped to withstand the violent pressure transients generated in shock tubes or transmitted from firing chambers. In addition the high natural frequency of undamped miniature flush-diaphragm instruments is retained. It measures pressures from 0-50 to 0-1000 psi with the operational. Case length: 49/64 inch. Width (between hexagonal sides): 1.0 inch. Weight: approximately 3 ounces. Output approximately 28 millivolts full scale open circuit at 7 volts (AC or DC) excitation. Non-linearity and hysteresis not more than ±1% of full scale. Statham Instruments, Inc., Los Angeles, Cal.

Circle No. 209 on Inquiry Card

Hi-Torque Size-8 Servo Motor

Size 8 servo motor developed to BuOrd specs has 0.35 oz. in. stall torque, 24,700 rad./sec.^{2} torque to inertia ratio, 26V fixed phase and 36V center tapped control phase for transistor applications, 6200 RPM no load speed and 13 tooth 120 pitch pinion. Rotor moment of inertia is 10 gm.cm.^{2}, length 1.2″ max. and weight 1.6 oz. John Oster Mfg. Co., Avionic Division, Racine, Wisconsin.

Circle No. 221 on Inquiry Card

The Second Annual

INSTRUMENT MOTOR SYMPOSIUM

sponsored by

Holtzer-Cabot Motor Division

National Pneumatic Co., Inc. will be held in Chicago during the week of the ISA Instrument-Automation Conference and Exhibit.

Theme: "Today's Trends—Tomorrow's Motors"

Speakers: Nationally-known instrument and motor design specialists. Open discussion will follow the prepared remarks.

When: 8:00-10:00 p.m., Tuesday, September 22.

Where: Palmer House, Chicago

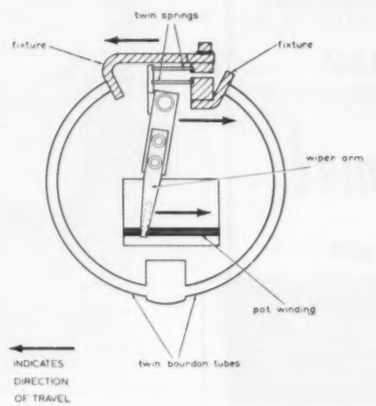
How to Register: Members and guests of the ISA may register at Holtzer-Cabot's exhibit (#368) at the International Amphitheatre on Monday or Tuesday or by writing earlier to the Symposium Chairman: R. H. Matthews, Chief Engineer, Holtzer-Cabot Motor Division, National Pneumatic Co., Inc., 125 Amory Street, Boston, Massachusetts.

PRESSURE TRANSDUCER

Spring Linkage Eliminates Friction Points

A new application of twin spring linkages eliminates pivots or bearings thereby doing away with friction points. Fairchild Controls' engineers designed their new transducer to have excellent repeatability characteristics while guaging absolute pressures in the 100-10,000 psi range.

Pressure sensing elements are twin Bourdon tubes which actuate the wiper of a wire-wound potentiometer that gives either linear or non-linear outputs. Overall accuracy including linearity, friction and hysteresis is 2%



Two Bourdon tubes actuate the wiper arm of the pot in Fairchild's new pressure transducer. Note twin spring linkage.

with resolution as low as 0.25%. The unit can withstand: 55 to 500 cps at 10g's vibration with less than 1% error; 2000 cps at 25g's without permanent shift in calibration; 25g's acceleration in each of 3 mutual perpendicular axes; and shock up to 25g's. Overpressure up to 100% of the unit's range is possible with negligible calibration shift.

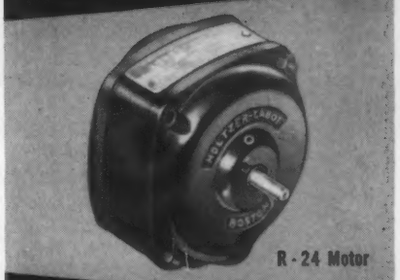
Circle No. 79 on Inquiry Card

Transparent, Flexible, Covers

Visual inspections and mechanical adjustments can now be made on hot or cold mechanical and electrical devices without exposing the controls or removing the rubrglas-seel. Rubrglas-seels are transparent, flexible covers made of tough glass-clear silicone. The material has an elongation (stretch) of 500%, and a temperature range from −160F up to 500F, is resistant to acids, ozone and sunlight, and has a shelf life in excess of 25 years. APM will mold rubrglas into flexible windows, lenses or transparent bellows to cover switches, control panels and other moving parts. A. P. M. Corp.

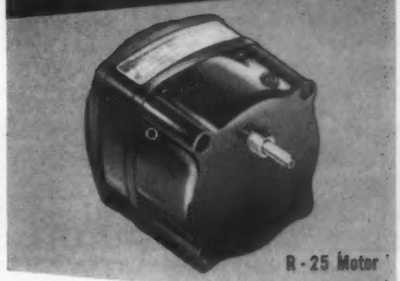
Circle No. 130 on Inquiry Card

HOLTZER-CABOT



R-24 Motor

Synchronous and Induction Capacitor Type Motors



R-25 Motor

R-24. Typical applications for this reversible, 4-pole induction motor are in servo mechanisms, as a balancing motor in recording instruments or as a control motor for voltage regulators. It has low rotor inertia for fast response applications. When operated 2 phase, it can be controlled electronically; or operated single phase as a permanent split capacitor motor.

R-25. Typical uses are for recording instruments, dictating and adding machines. Approximately 2½" in diameter, it is available in either induction or synchronous construction with reversible rotation.

Both the R-24 and R-25 are available with gear case speeds from 1/2 to 3600 RPM, torque ratings up to 75 oz. inches or higher, and single phase, 2 or 3 phase.

HOLTZER-CABOT ESTABLISHED HC NP

HOLTZER-CABOT MOTOR DIVISION
NATIONAL PNEUMATIC CO., INC.
125 Amory Street, Boston 19, Mass.

GENTLEMEN: Please send me data sheets on the Holtzer-Cabot R-24 and R-25 Size Motors.

Please have representative call _____ (date)

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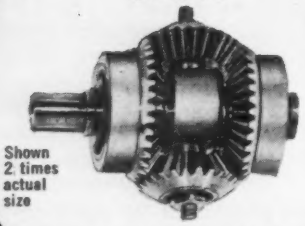

1/16 & 1/8"

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DYNACO STOCK · HOLLOW SHAFT · FACE GEAR · END GEAR

Cat. #HSD559-4 shown for mounting on .062" shaft, (4) ABEC 1 ball bearings, clearance dia. 0.580", displacement 15° arc.

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DYNAMIC GEAR CO. INC.
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CIRCLE 21 ON INQUIRY CARD

SYSTEMS DESIGN

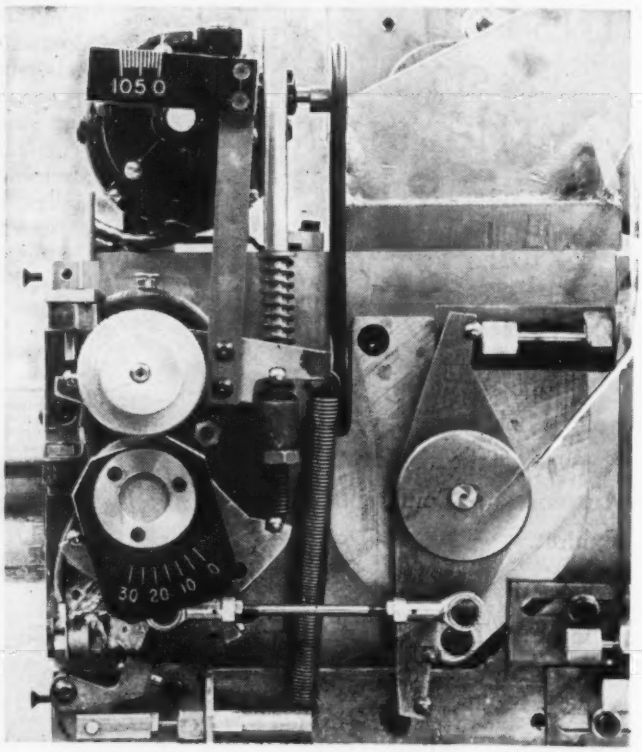

Fig. 1. Direct approach based on the use of a mechanical stop which incorporates the electrical sensing element. This takes the form of a fixed stop which is completely insulated electrically from the machine. A small d-c voltage is applied to this insuated stop at all times. When the feed lever contacts the stop at the end of grind, it serves to short the d-c voltage to the grounded machine bed.

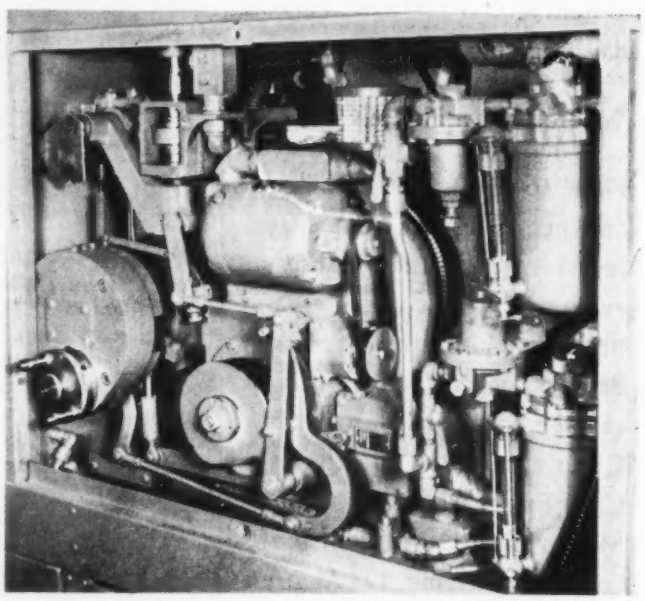

Fig. 2. Complex approach to design problem. The mechanical stop is in the trunnion housing. The feed motor drives a cam shaft which carries two separate cams; one to operate the lever which rotates the feed nut, and the other to actuate the limit switch which signals the feed is complete. Although this feed mechanism has performed well, it is complicated.

THE DIRECT APPROACH:

Electronic Sensing Replaces Conventional Limit Switch

D. V. Dickey of Bryant Chucking Grinder Co. of Springfield, Vt. believes that design problems are generally attacked from several angles: the mechanical designer attacks it from one direction, the hydraulic designer from another, and frequently the electrical designer works his equipment into a mechanism whose design concepts have been finalized even though the electrical equipment performs an important function in controlling the timing, sequencing and motions of the mechanism. Bryant engineers, he says, applied a different approach in the development of a new machine for grinding very small holes.

One major problem dealt with means of terminating a crossfeed motion at the end of the grinding operation on each part. The cross-feed mechanism, Fig 1 is incorporated into the wheelslide, and is supported between a pair of trunnions whose center-line is in the same plane and at right-angles to the wheelslide center-line. Cross motion is gained through a screw and nut arrangement. Normal feed motion occurs by rotating the nut back and forth; advancing the screw through the nut compensates for wheel wear and "dress off", A 1/50-hp variable-speed d-c motor drives the nut, but an overrunning clutch arrangement allows pneumatic pistons to override the motor's action for quick approach and backoff.

In a typical cycle, the quick approach piston moves the crossfeed to rapidly bring the wheel to a few ten-thousandths of the surface to be ground. The feed motor then assumes its function of advancing the grinding wheel into the workpiece during stock removal. After the grinding is complete, the backed piston returns the cross-feed to the traversing position. Feed-motor speed control is accomplished through a pair of power-stat-rectifier armature supplies; these and a timer provide an automatic two-speed feed arrangement.

The cross-feed lever, which rotates the feed nut, contacts a fixed mechanical stop when the required amount of stock has been removed. Since this mechanically fixes the end of the infeed motion, the electrical controls, at this point, throw the machine into the next portion of the cycle. The usual way of electrically sensing this point is to locate a limit switch somewhere on the cross-feed mechanism, requiring an auxiliary lever or some other plan to operate the switch at approximately the same moment that the mechanical stop is touched. Quite often, the mechanical design is complicated to mount and operate the switch for the desired function. In addition, some method for adjusting the switch position is necessary which can be a source of field trouble due to maladjustment by personnel not thoroughly familiar with the switch application.

ELECTRONIC CIRCUIT

A simple electronic circuit senses the contact between feed lever and insulated stop, Fig 3. The heart of this circuit is a gaseous thyratron tube 5696. To insure that the tube cannot conduct, a negative voltage of sufficient magnitude is applied to the grid through a grid resistor. The insulated mechanical stop is maintained above ground potental, negative grid bias is applied to the tube; therefore, the tube cannot fire. However, when the feed lever, which is grounded to the machine contacts the insulated stop, the negative grid bias shorts to ground. The grid then becomes sufficiently positive and the tube conducts.

A sensitive d-c relay connected in the plate circuit of the

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CIRCLE 22 ON INQUIRY CARD

push-pull CONTROLS

Compression & Tension Type

Aircraft cable is strung with spherical steel shells in a rigid or flexible housing sealed with "O" rings. 3" standard bend radius. ¾" minimum bend radius.

Three Types:

1. *Light Duty*—Compression Ult. Load 1250 lbs.; Ult. tension 960 lbs.
2. *Heavy Duty*—Compression Ult. Load 1650 lbs.; Ult. tension 960 lbs.
3. *Extra Heavy Duty*—Compression Ult. Load 3050 lbs.; Ult. tension 3900 lbs.

Positive remote controls for actuating mechanical, hydraulic or other devices. Eliminate bell cranks, pulleys, and dual cables. U.S. Patent No. 2441719. All world rights reserved. Send for ENGINEERING MANUAL giving complete specifications covering materials, finishes, capacities. Please address Dept. EMD-PP-59.

SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

CIRCLE 23 ON INQUIRY CARD

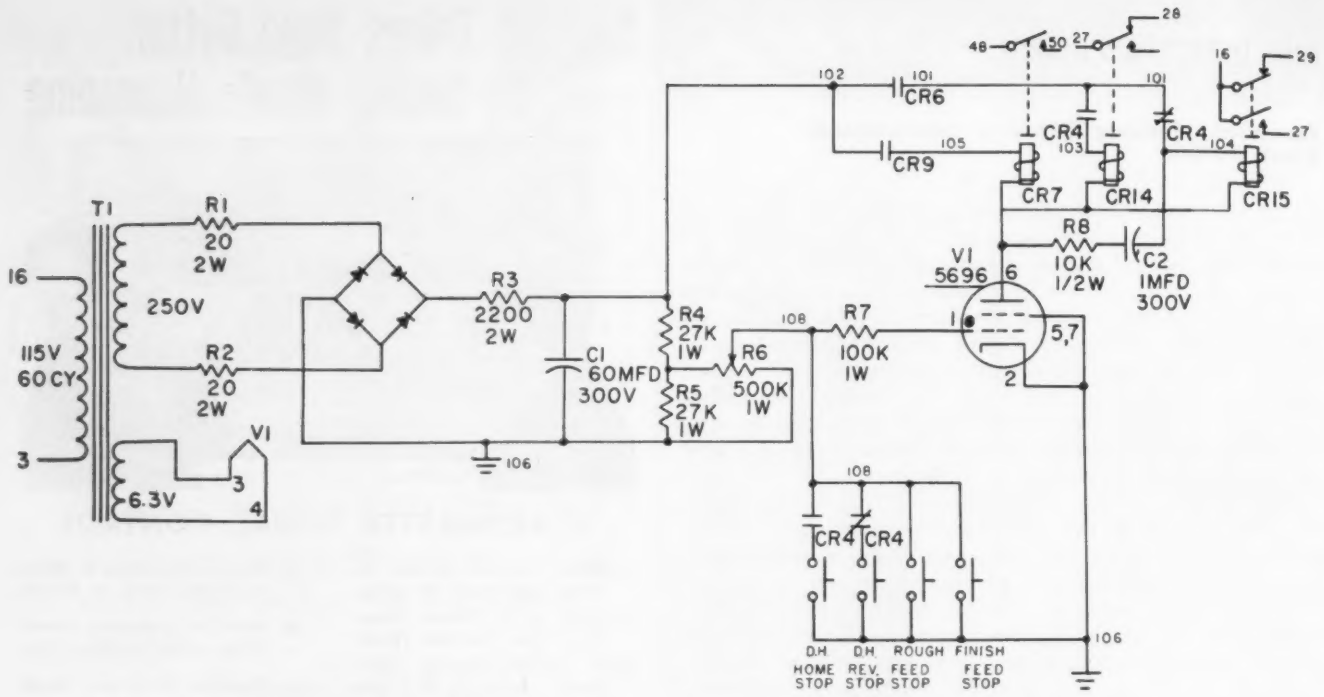


Fig. 3. Electronic switching circuit used in conjunction with insulated stops.

thyratron tube eliminates the need for an electronic amplifier to raise the tube's required output to operate a conventional relay or solenoid.

In selecting the 5696 tube, consideration was given to its inherent "latch-in" operation common to most thyratrons. Normally, the grid is maintained negative until it is desired to have the tube conduct. Then the grid is allowed to go sufficiently positive for conduction to start. Once the thyratron has fired, the grid can no longer be used to control the tube. Except in some critical areas of high negative grid voltage and very low plate current, increasing the grid voltage in the negative direction has no effect on the conducting tube. Hence, the only way to bring the tube under grid control is by interrupting the plate cathode circuit to stop conduction. This can be done with relay contacts.

If the "latch-in" feature is not required, or if it is objectionable or impractical to provide ways of opening the plate-cathode circuit of the tube, a somewhat similar circuit that uses a nongaseous tube can be substituted, Fig 4. Where it is impractical to open the plate-cathode circuit of the tube, at the approximate time, Bryant Chuck Engineers changed to a circuit using a 12AU7 dual triode tube. They selected the 12AU7 to simplify the circuit. One-half of the tube is used as a rectifier; the other half as the control element. To simplify further, a dual chassis-mounted capacitor was used to replace the two single capacitors in the previous circuit.

Since this type of tube can be controlled by grid voltage alone, their application was also simplified. Plug sizing requires the use of an insulated stop, similar to the feed stop described, at ground potential until the plug enters the part. Thus, the ground is removed. The grid of the tube is held negative to keep the tube cutoff by shorting R4 to ground. However, when the plug enters the bore of the workpiece, which indicates the correct part size, the shorting path to ground is opened, and the grid goes positive to allow the tube to fire. To stop conduction, the negative grid bias is restored by shorting R4 to ground. The plate-cathode circuit need not be broken.

Besides being simple, the two electronic circuits described are extremely versatile. Since the grid controls the tube's output, almost any type of low-power low voltage signal may be applied to the grid and used to obtain circuit outputs capable of operating conventional control components. The signal may come from a limit switch, a photoelectric device, a microphone or other suitable sources.

Circle No. 83 on Inquiry Card

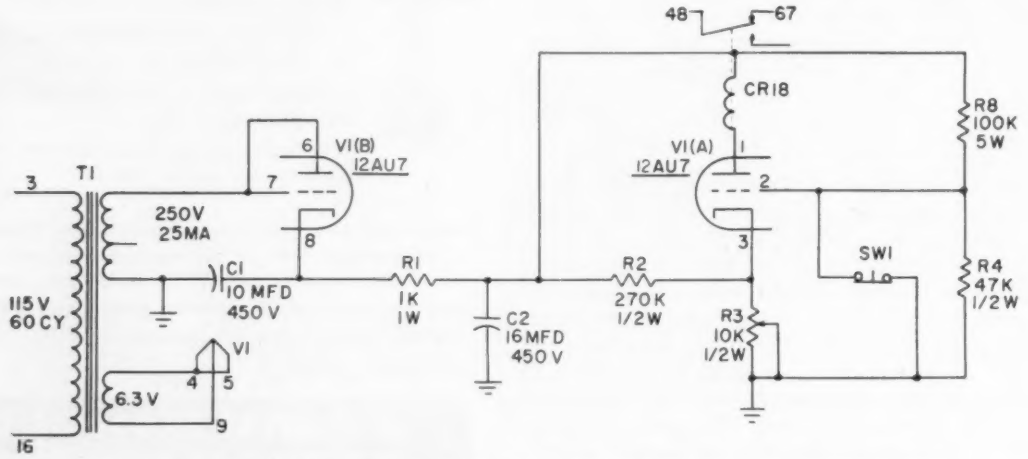
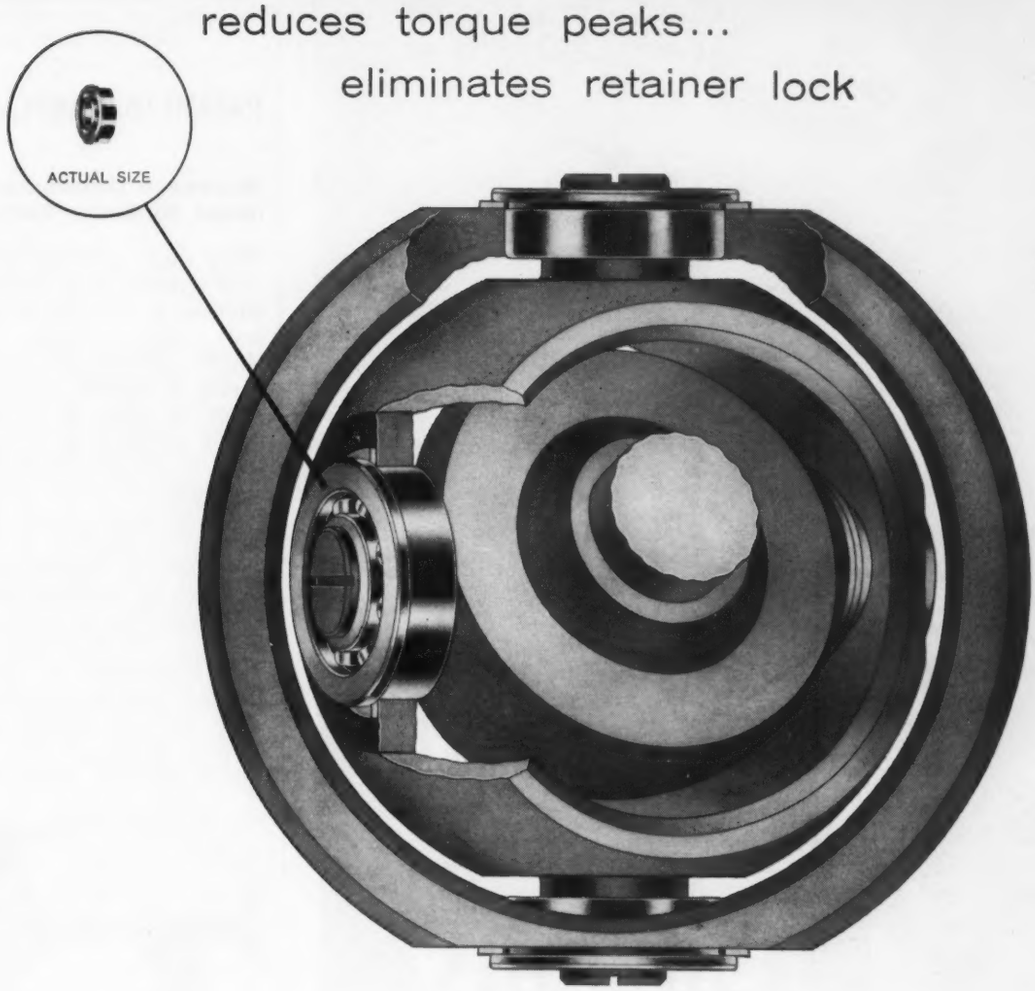


Fig. 4. A second electronic switching circuit which uses a nongaseous tube.

BARDEN "W" retainer reduces torque peaks... eliminates retainer lock



Low-torque reliability for gyros, synchros and other torque-sensitive components

"W" retainer bearings are available flanged or unflanged, shielded or open, in sizes most in demand ⅝" O.D. and under. For complete technical information write for engineering data sheet W-1.

An instrument bearing that passes all normal torque tests can develop excessive torque peaks in operation. In gyro gimbals, synchros and similar applications the result is erratic component performance. To solve this reliability problem, Barden developed the "W" ball retainer.

Field tested and proved in actual operation, Barden "W" retainer bearings are specified for a growing number of torque-sensitive applications. • • • *In gimbals on the Sidewinder they contribute to the missile's reliability.* • • • *In attitude gyros they save one manufacturer $100 per unit by reducing costly teardown.*

Like other Barden advances in engineering and manufacturing, "W" retainers answer a specific performance problem. Other Barden Precision ball bearings satisfy such extreme demands as:

- High temperatures (to above 400°F)
- Low torque (to 10 dyne-cm. for 2 lb. load)
- High speeds (to over 300,000 RPM)
- Concentric rotation (to .00005" max. T.I.R.)

The complete Barden line includes sizes from .0469" bore to over 3" O.D., all manufactured to Barden Precision standards of dimensional accuracy, uniformity and reliability. Refer to Sweet's Product Design File (8h/Ba) for Barden catalog and bearing selection guide.

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Western office: 3850 Wilshire Boulevard, Los Angeles 5, California.

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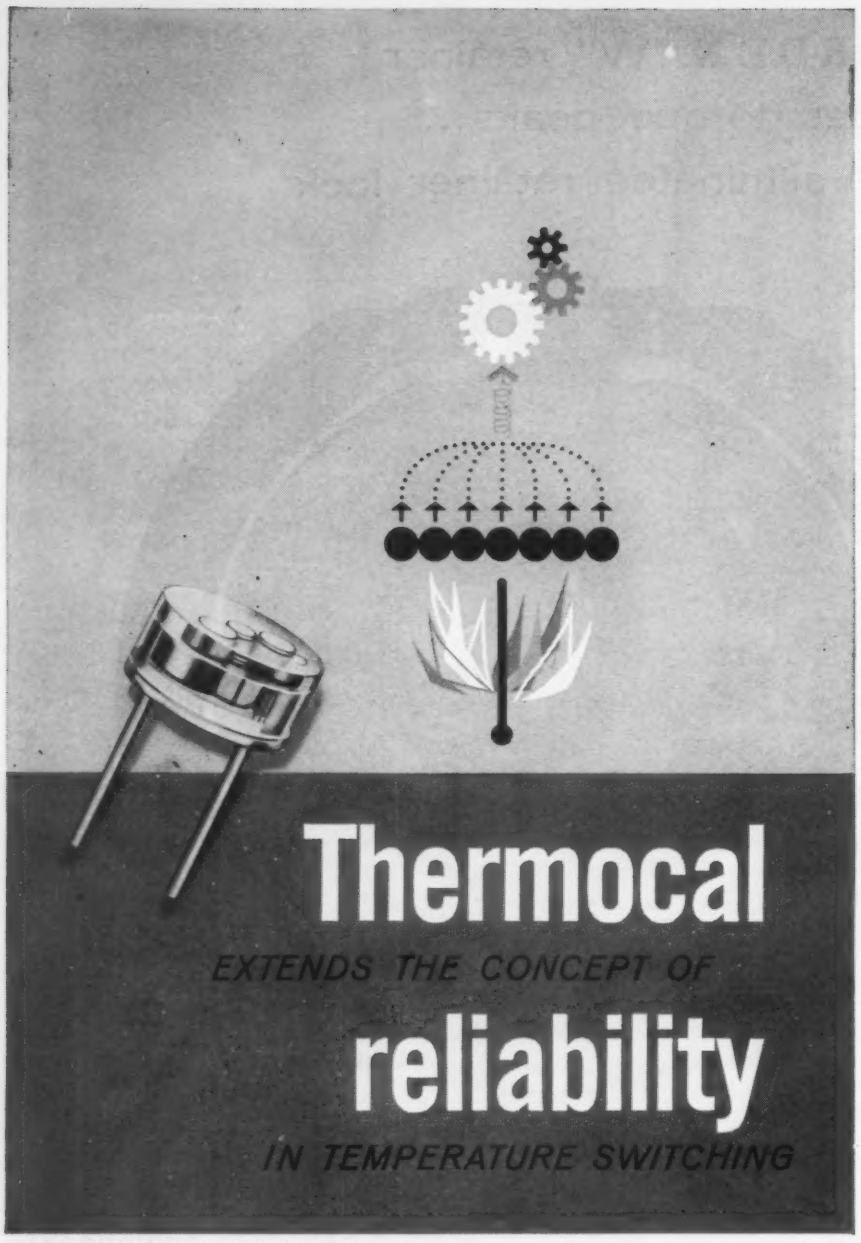

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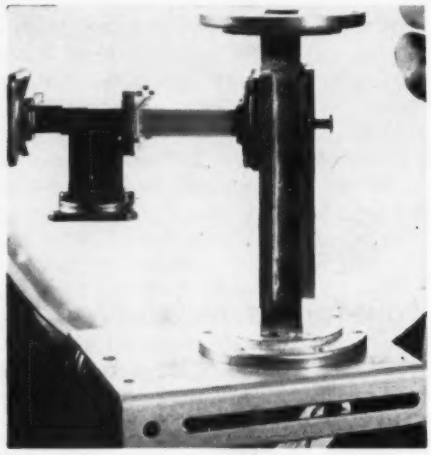
SYSTEMS DESIGN

PARAMETRIC AMPLIFIER

Microwave Development Doubles Range Of Radar Systems

Many major problems of jet age aircraft control can be solved by a simple addition to existing ground and aircraft radar systems, according to Hughes Aircraft Company. Their new device is capable of increasing radar range as much as 100%. The parametric amplifier, or paramp, is a low-noise microwave amplifier particularly applicable to radar and communications. Although several forms of the parametric amplifier have been proposed and investigated experimentally, emphasis is currently focused on the diode amplifier; it possesses several advantages over other types.

A comparison of the parametric amplifier with the conventional microwave receivers reveals a number of distinct advantages for the paramp. One of the most important is the improvement in the noise level by three to eight decibels over the best superheterodyne receivers, increasing radar ranges by 100%. A second major advantage lies in improved overload characteristics. The paramp amplifies smaller signals than the conventional receiver and at the same time stands higher incident power levels without burnout or degradation of performance, alleviating the duplexing problem which exists in present radar systems.



Hughes Aircraft's new parametric amplifier increases the range of existing airport and aircraft systems by as much as 100%.

Paramps utilize the same principles as vacuum tube amplifiers with two distinct differences: in the paramp, microwave power is obtained from a

microwave power source at an appropriate frequency at least twice the signal frequency; and the amplifying unit is a solid state material.

Variable impedance is simultaneously a parameter in three circuits. One circuit handles the signal frequency, one the pump frequency, and one the idler frequency. Idler frequency is equal to the difference between the pump and the signal frequencies. The nonlinear variation of this parameter is a function of the applied voltage leads to the amplification of the input signal.

Action of the non-linear element is to convert part of the pump power into power at the idler frequency. The idler signal reacts back on the nonlinear element and recombines with the pump power to produce another frequency equal to the difference between the pump and idler frequencies. Since this is precisely the signal frequency a part of the pump power has been converted to signal power, or the signal has been amplified.

Although experimental models have been built from a frequency of 200 megacycles a second to a frequency of 10,000 megacycles per second, an average unit amplifies the signals at about 2800 megacycles per second, with the higher pump frequency operating at 10,000 megacycles per second. The paramp is only 8" long, 6" high, and 1" thick and is placed between the search antenna and the transmitter and receiver units.

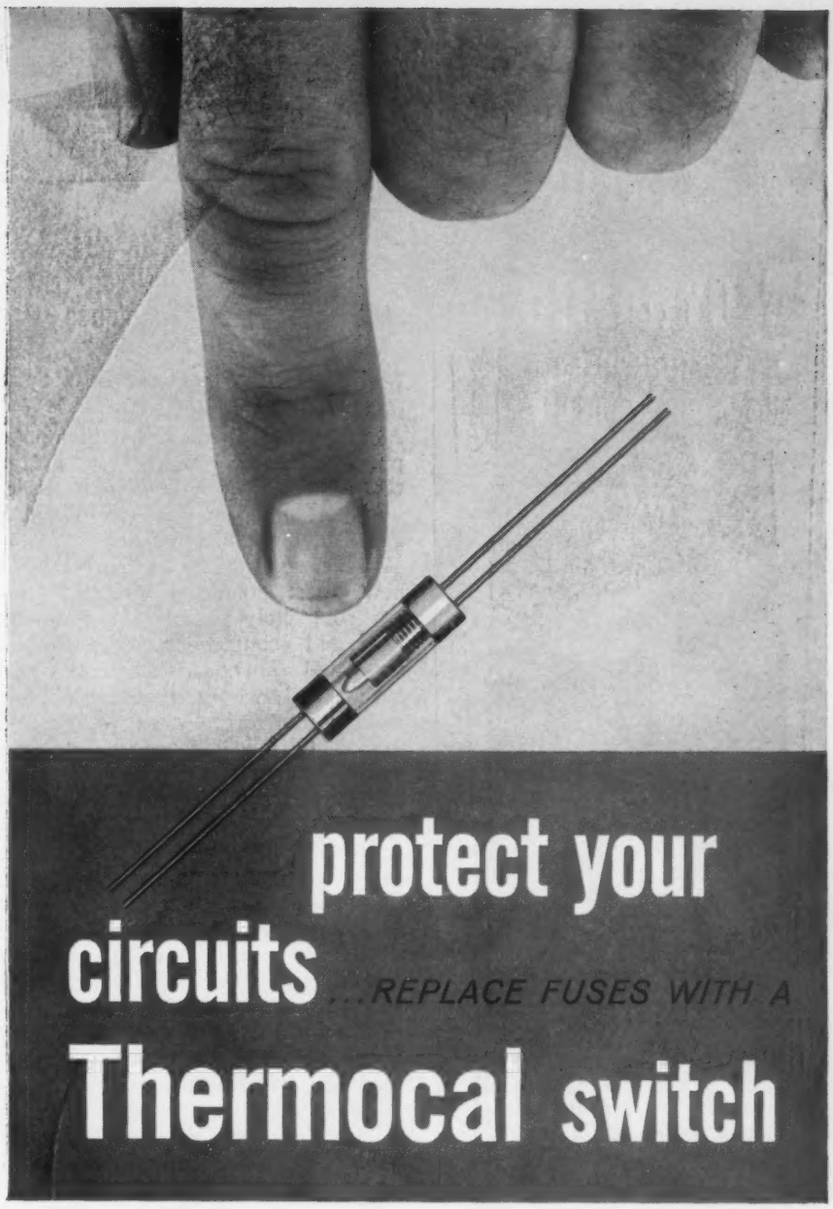
The greater sensitivity provided by paramp, would not only increase radar range by as much as 100%, but would also permit close range detection of vague or previously undetectable targets such as small business planes and small military jets. The increased range in paramp adapted radar systems would inform jet cruiser weather disturbances much earlier and help pilots to avoid them.

Circle No. 85 on Inquiry Card

X-Y Recorder

X-Y recording, beyond the limits of electromechanical plotters, is done with a recorder that uses optical galvanometers, a light beam trace and immediate-developing direct print paper charts. Recordings of families of transistor curves, or of rapid mechanical displacement, velocity and acceleration are made by an ultraviolet light beam on 8" x 8" charts. Specs: writing speeds in excess of 2500 in/sec, overall frequency response of 3 db down at 130 cps, linearity of 1% of full scale and sensitivity as high as 62.5 uv/in. Sanborn Co., Waltham Mass.

Circle No. 141 on Inquiry Card



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Statham

CIRCLE 27 ON INQUIRY CARD

New Packaging Techniques

Molded Wiring Harness Cuts Space, Improves Performance

A new wiring method that eliminates many electrical problems in today's electronics-packed aircraft and missiles will be used in Chance Vought's F8U-2N, the company's newest in the Crusader series of aircraft. In Vought's new system, bundles of insulated wires are completely encased in a tough, rigid and compact cover of resin-impregnated fiberglas. This stick-like, hard-coated wiring harness can be molded into virtually any shape and formed to follow structural contours inside the aircraft. It requires less than half the space needed for conventional harnesses.

Since the fiberglas covering is tough, heat-resistant and can be molded into many shapes, harnesses can even take the form of an aerodynamic fairing for use outside an aircraft, missile or space vehicle. The new system is expected to solve several of the principal problems of today's wiring methods; broken wires, chafing and crowded installations. It requires minimum maintenance, is abrasive-resistent and resists accidental damage. Weight is considerably less than that of conventional harnesses.

A conventional harness consisting of 360 wires of a given gage forms a bundle 2⅝ inches in diameter or, if divided into six smaller bundles, a package 3⅜ inches high and 2¼ inches wide. By contrast, the same number of wires or the same gage can be carried in a molded harness section only 1½ inches wide and 1⅝ inches high.

Wires encased in the molded harness can carry higher voltages, withstand much higher temperatures and electrical overloads, and tolerate vibration far better than conventionally- harnessed wires. Tests of the new harness have shown that if an individual wire is overloaded because of equipment failure it invariably fails outside the molded section. Fire hazard is lessened and the trouble spot is easy to locate.

Encased in the fiberglas, the cable assembly passed 6,000 volt wire-to-wire potential with 10 mil wire, double the amount normally specified for wire of this gage. It stayed within operating limits for the insulation at ambient temperature of 400F while carrying rated current in 20 per cent of the wires. Dielectric strength was tested to 6,000 volts without failure when the harness was heat soaked for 200 hours at 400F. Twenty-two gage, five-ampere rated wire was overloaded to 35 amps for two minutes and showed no damage to the harness or adjacent wires inside. The harness was vibrated from five to 2,000 cycles per second at 10G for nine hours without failure.

The molded harness can be designed into an aircraft much as is a structural member. Its location can be predicted within a few 100ths of an inch,

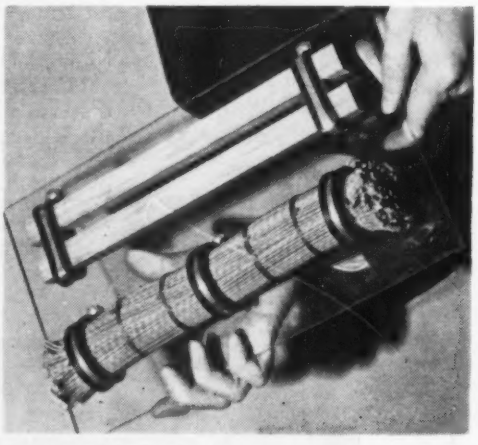

Fig 1 Sections of conventional aircraft wiring harness (left) and Vought's new hard harness wiring system that carry approximately the same number of wires of the same gage as the conventional section yet occupy far less space.

Fig 2 Flexible covering is used in areas where wires leave rigid, fiberglas-covered harness to branch off to another area or to make connection.

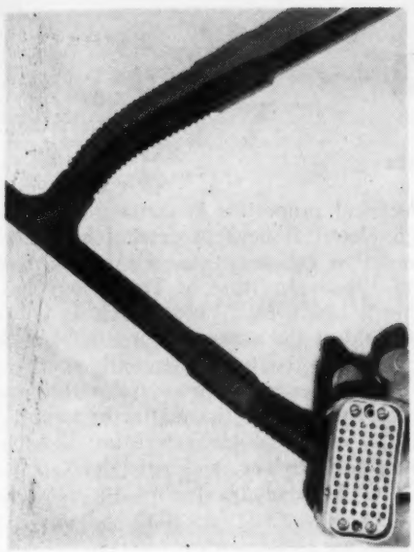

Fig 3 Flexible tubing covers wires as they separate from one section of fiberglas-covered hard harness (square areas) to branch off to another area or to terminate at a connection.

an accuracy impossible with the loose-wire harness which was snaked through the aircraft interior. Should replacement of a harness section be necessary, a true, made-to-fit spare can be supplied. Junction boxes are strategically located to facilitate replacement.

Extra wires in the molded harness provide for installation of additional equipment or serve as spares. The design permits incorporation of electrical or electronic system changes with far more ease than does conventional wiring and eliminates the need for splicing or running new wires along the bundle. Conventional wiring could be added alongside the bundle, however, for a special situation.

Fabrication of the hard harness requires relatively simple tooling, and the harness can be tailored by the aircraft manufacturer to any particular aircraft or missile. The system is expected also to have application in computers and other high-density electronic equipment, as well as in external wiring for factories, office and homes. Surface ships, submarines, tanks, large earth-moving machines and even the family car are other units in which application is envisioned.

Unlike the conventional harness system in which each wire is coded as well as numbered, the hard harness uses a neutral numbering system which greatly increases the circuit flexibility of the molded cable assemblies. Since circuit identification no longer is required, any new wire now can be used in a circuit without the need for re-identification of the cable assembly, a requirement which formerly created extensive paperwork and frequent confusion.

Circle No. 122 on Inquiry Card

Electronics Engineers:

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PH VIII	2^{13}, 2^{12} (Special)
PH VI	one part in 2000, 1000 or 500
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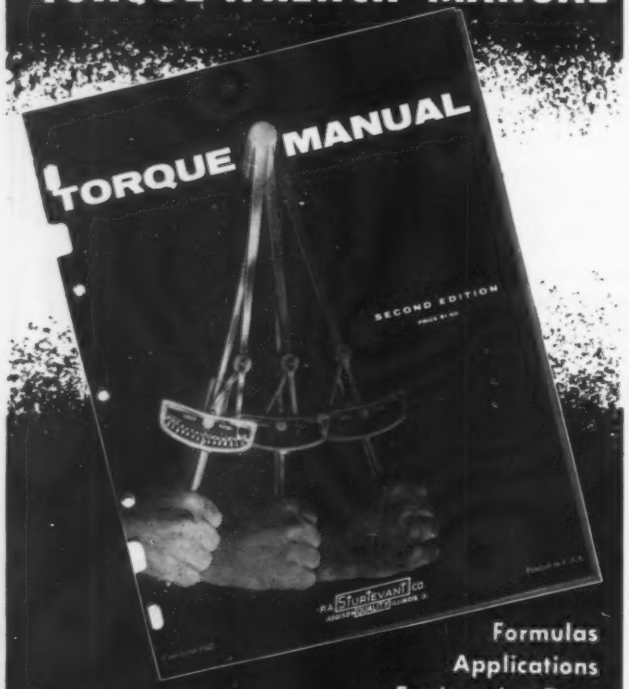
CIRCLE 32 ON INQUIRY CARD

"TORQUE WRENCH" MANUAL



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General Principles

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MATERIALS

Plastic Experiments

Improvements of electrical properties in commercial plastic materials through electrical field processing has been advanced. Experimentation by scientists of Armour Research Foundation of Illinois Institute of Technology has shown that processing a commercial plastic such as polystyrene in an electric field at the same time it is subjected to external heating increases the tensile strength approximately 25 per cent. This evidence has prompted ARF electrical engineers to look further into the matter of improving the mechanical and electrical characteristics of such plastics as polystyrene, polyethylene, and vinylidene, chloride. Illinois Institute of Technology, Technology Center, Chicago, Illinois.

Circle No. 256 on Inquiry Card

Lacquers for Vacuum Metallizing of Polystyrene

New lacquers for application before and after the deposition of aluminum in the vacuum metallizing of polystyrene provide high reflectance, high abrasion resistance and eliminate embrittlement and flake off. Both lacquers are easily applied by simple spraying, dipping or flow-coating. Schwartz Chemical Co., Inc., Long Island City, New York.

Circle No. 254 on Inquiry Card

Insulated Rod for High Torque

New high strength, paper base Insurok laminated plastic sheathing solves the torque problem so common to variable transformers and other equipments which require an insulated shaft that must withstand the mounting of components and operate under high resistance. Solidly anchored to the metal rods, the sheath accepts multiple set screw mountings of components without chipping or cracking. Insurok insulated steel rods are readily available in a wide range of lengths and diameters—and in varying degrees of insulation thicknesses. The Richardson Co., Melrose Park, Illinois.

Circle No. 246 on Inquiry Card

Custom Engineered Plastic Moldings

Brochure on standard, special, and newly developed types of plastic moldings covers basic cold molded compositions as well as new hot molded formulations to reduce size requirements for electrical moldings. The new bulletin outlines the history of the development of "Rosite," a stone-like molding compound with properties useful for electrical applications. Properties include basic resistance to heat, inherent arc-quenching capability, non-tracking characteristics, and high dimensional stability. Rostone Corporation, Lafayette, Indiana.

Circle No. 249 on Inquiry Card

WORTH FILING

Stainless Fasteners

Cap screws and bolts; nuts; washers; machine screws; wood screws; set screws; sheet metal screws in dotted and Phillips head; rivets; cotter pins; piano hinges; pails; funnels; scoops; and screw machine products of stainless steel.

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COMPONENTS DIGEST 7

Performance Characteristics of

ANALOG-DIGITAL CONVERTERS Part III

This concluding portion of Components Digest 7 tabulates physical and performance characteristics of commercially available analog-digital converters with shaft or voltage inputs. These converters supply outputs in either parallel or serial form in a convenient digital code for use with digital computers or suitable output devices. For complete coverage, the scope is limited strictly to converters; digital voltmeters which constitute a particular class of converter with visual read-out are not included.

Parts I and II of Analog-Digital Converters (June and July issues) reviewed the principles of operation covering important factors as well as distinguishing features of the different types. In particular, Part II discussed optical and brush-type shaft angle encoders, as well as the principal operating characteristics of voltage-to-digital converters. Examples showed the importance of conversion speed with respect to accuracy in systems with varying inputs. Part I had previously described general principles and circuits with emphasis on techniques for avoiding ambiguity.

The following tables describing commercial types are presented primarily as a guide to what is available, from whom. In many instances only a representative portion of a manufacturer's line could be included. This fact, as well as the obvious difficulty in presenting data on different types of equipment in a uniform tabular notation indicates the importance of extensive direct discussion with individual manufacturers prior to a final selection.

Buyers' Guide For Analog-Digital Converters

ADAGE, INC.
292 Main St., Cambridge, Mass.

APPLIED SCIENCE CORP. OF PRINCETON
Princeton Junction, Princeton, N.J.

B & H INSTRUMENT CO., INC.
3479 W. Vickeny Blvd., Ft. Worth, Tex.

BALDWIN PIANO CO.,
1801 Gilbert Ave., Cincinnati, Ohio

C G ELECTRONICS CORP.
P O Box 8345, Albuquerque, N. M.

CHESAPEAKE INSTRUMENT CORP.
Shadyside, Maryland

COLEMAN ENGINEERING, INC.
Torrance Blvd., Torrance, Cal.

COLORADO RESEARCH CORP.
Broomfield, Colorado

DATEX CORP.
1307 So. Myrtle Ave., Monrovia, Cal.

DAYTON INSTRUMENTS, INC.
404 Winston Ave., Dayton, Ohio

DIGITRON CO.
45 W. Union St., Pasadena, Cal.

DYCHRO CORP.
12 Centre Ave., Newton, Mass.

DYNAMICS RESEARCH CORP.
44 Winn St., Woburn, Mass.

ECLIPSE-PIONEER, Div. Bendix Aviation
Route 46, Teterboro, N. J.

ELECTRO-MEC LABORATORY, INC.
47-51 33rd St., L. I. City, N.Y.

EPSCO, INC
275 Mass. Ave, Cambridge, Mass.

FRANKLIN ELECTRONICS, INC.
East Fourth St., Bridgeport, Pa.

W. & L. E. GURLEY,
514 Fulton St., Troy, N.Y.

HOOVER ELECTRONICS, INC
110 West Timonium Rd., Timonium, Md.

INSTRUMENT DEVELOPMENT LABS, INC.
66 Mechanic St., Attleboro, Mass.

KEARFOTT CO., INC.
1500 Main Ave., Clifton, N.J.

LITTON INDUSTRIES
5873 Rodeo Rd., Los Angeles, Cal.

LIBRASCOPE, INC.
40 E. Verdugo Ave., Burbank, Cal.

F. L. MOSELEY CO.
409 N. Fair Oaks Ave., Pasadena, Cal.

NORDEN, Div. United Aircraft
Wiley St., Milford, Conn.

NORWOOD CONTROLS
936 Washington St., Norwood, Mass.

SOUTHWESTERN INDUSTRIAL ELECTRONICS
2831 Post Oak Rd., Houston, Texas

TOLLER & COOPER, INC.
75 Front St., Brooklyn, N.Y.

TELECHROME MFG. CORP.
28 Ranick Dr., Amityville, N.Y.

WAYNE GEORGE CORP.
1117 Commonwealth Ave., Boston, Mass.

WEST COAST RESEARCH CORP.
2371½ Westwood Blvd., Los Angeles, Cal.

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CIRCLE 34 ON INQUIRY CARD

Summary of Physical and Performance

MANUFACTURER	MODEL	TYPE INPUT	VOLTAGE INPUT RANGE	TYPE READOUT	NUMBER SYSTEM	NUMBER OF DIGITS	ACCURACY
ADAGE, INC.	V9-AB	Voltage	Full scale: 1,10,100 volts	Parallel, serial	Binary, octal	9 binary plus sign 3 octal plus sign	± 0.05% ± 1/2 least significant digit
ADAGE, INC.	VR10-AB	Voltage	Full scale: 1,10,100 volts	Parallel, serial	Binary	11 including sign	± 0.05% ± 1/2 least significant digit
ADAGE, INC.	V12-AB	Voltage	Full scale: 1,10,100 volts	Parallel, serial	Binary, octal	12 binary plus sign 4 decimal plus sign	0.01% relative ± 1/2 least digit. Varies only 5 ppm/°C change
ADAGE, INC.	V12-AD	Voltage	Full scale: 1,10,100 volts	Parallel, serial	Decimal, binary coded decimal	4 decimal including sign	0.05% ± 1/2 least significant digit
ADAGE, INC.	V16-AD	Voltage	Full scale: 1,10,100 volts	Parallel, serial	Decimal, binary coded decimal	5 decimal including sign	Relative 0.01% at room temperature. Varies 5 ppm/°C change
APPLIED SCIENCE CORP. OF PRINCETON	EPD8G	Shaft		Parallel	Gray	8	1 part in 256
B & H INSTRUMENT CO., INC.	BH100	Shaft			Decimal	5	0.05% of reading
BALDWIN PIANO CO.	A21SP18	Shaft		Parallel	Gray	18	1 part in 262,144
BALDWIN PIANO CO.	B2.6SS13	Shaft		Parallel	Gray	13	1 1/4 parts in 8192
BALDWIN PIANO CO.	A4DP13	Shaft		Parallel	Gray	13	1 part in 8192
BALDWIN PIANO CO.	AGDP13	Shaft		Parallel	Gray	13	1 part in 8192
BALDWIN PIANO CO.	A9SP16	Shaft		Parallel	Gray	16	1 part in 65,536
C G ELECTRONICS		Voltage	0 to 10 v, or −5 to +5 v	As required	Binary coded decimal		0.2%
CHESAPEAKE INSTRUMENT CORP.	ADC-100-5	Voltage	0 to 50		Optional	5 visual, 3 tape	± 1 part in 100,000
COLEMAN ENGINEERING, INC.	A3DUT, A4DUT A5DUT, A6DUT	Shaft			Decimal	3,4,5, or 6, No depends on model	1 count in full scale
COLORADO RESEARCH CORP., WITH NORDEN DIV., UNITED AIRCRAFT	110	Shaft Angle		Parallel	Decimal, binary coded decimal	6 decimal (360,000 counts per shaft turn)	1 part in 2^{18} to 2^{19}
DATEX CORP.	C711	Shaft		Parallel	Special nonambiguous code	5 decimal (equivalent)	1 part in 1000
DAYTON INSTRUMENTS, INC.	D1-3,4,5,6 (4 units)	Shaft		Parallel	Decimal	3 to 6	$1/10^n$ (n = number of digits)
THE DIGITRAN CO.	7101	Shaft		Visual in-line decimal contacts	Decimal	3, 4, or 5	1/1000 to 1/100,000
DYCHRO	DV-13A	Shaft		Parallel	Gray	13	± 2.5 minutes arc
DYCHRO	DV-SC11A	Shaft		Parallel	Gray	11	1 part in 2^{11} of sin and cos
DYNAMICS RESEARCH CORP.	PH7	Shaft		Incremental (2 phase)		2048 counts per rev.	0.01% of a revolution
ECLIPSE—PIONEER	GS-4-A1	Shaft		Parallel	Binary	7	1 part in 128
ECLIPSE—PIONEER	GS-5-A1	Shaft		Parallel	Gray	8	1 part in 256
ECLIPSE—PIONEER	GS-6-A1	Shaft		Parallel	Gray	13	1 part in 8192
ELECTRO-MEC LABORATORY, INC.	Type 15-E-8	Shaft		Serial, parallel	Gray	8	± 1/4 digit
ELECTRO-MEC LABORATORY, INC.	Type D30I-9	Shaft		Serial, Parallel	Gray	9	± 0.5 digit
ELECTRO-MEC LABORATORY, INC.	Type D30H-10	Shaft		Serial, Parallel	Gray	10	± 0.8 digit

Characteristics of Analog-Digital Converters

SAMPLING RATE	SIZE	WEIGHT	INERTIA	FRICTIONAL TORQUE	SPECIAL FEATURES
To 2000 conversions/sec	5 1/4" panel space in standard RETMA relay rack				Visual nixie octal display. Converts to V12-AD by interchanging 4 printed circuit cards. Modular design for full versatility. Input impedance to billions of ohms available.
8000 conversions/sec	5 1/4" panel space in standard RETMA relay rack				Visual display available. Modular design for full versatility. Input impedance to billions of ohms available.
To 1000 conversions/sec	5 1/4" panel space in standard RETMA relay rack				Visual nixie octal readout. Converts to V16-AD by interchanging 5 printed circuit cards. Modular design for full versatility. Input impedance to billions of ohms available.
2000 conversions/sec	5 1/4" panel space in standard RETMA relay rack				Visual nixie readout. Converts to model V9-AB by interchanging 4 printed circuit cards. Modular design for full versatility. Input impedance to billions of ohms available.
To 1000 conversions/sec	5 1/4" panel space in standard RETMA relay rack				Visual nixie readout. Modular design for full versatility. Converts to model V12-AB by interchanging 5 printed circuit cards. Input impedance to billions of ohms available.
10,000 rpm	2 1/4" dia. x 1 1/4"	8 oz.	70 gm-cm^2	0.05 oz-in. starting	Code is permanent magnetic field on a ferrite disc. Very long life and highest reliability in extreme environments.
1/sec	3" x 5" x 5 3/4"	2 1/2 lbs.	0.1 oz-in^2	0.05 oz-in.	Linear, parabolic, logarithmic functions displayed in direct digital relation; compound ranges, plus & minus scales from zero, suppressed ranges.
100/sec	21" dia. x 7 3/4"	169 lbs.	435 lb-in^2	800 oz-in max.	Optical, include transistor output amplifiers.
To 200 kc	2 9/16" dia. x 3 3/4"	1 1/4 lbs.	125 gm-cm^2	1 oz-in max.	Optical, subminiature.
To 100 cps	4" dia. x 6 1/2"	9 1/4 lbs.	500 gm-cm^2	0.5 oz-in	Optical, include transistor output amplifiers, non-linear codes available.
To 100 cps	8 3/16" dia. x 8 3/4"	14 lbs.	3000 gm-cm^2	3 oz-in	Optical, high gain transistor output amplifiers for remote transmission,
To 100 cps	9 1/16" dia.	17 1/2 lbs.	18.2 lb-in^2	16 oz-in max.	Optical, high gain transistor output amplifiers for remote transmission.
100 to 300 cps	232 to 405 cu. in.	7 to 9 lbs.			PCM operation, transistorized.
100 kc	11" x 19" x 17"	32 lbs.			Visual and 5-channel tape output.
2/sec	7.00" x 4.60" x 1.25" max.	2.5 lbs. approx.	176 gm-cm^2; 10 oz-in max. breakaway	0.1 oz-in running	Non-ambiguous, retractable brushes.
Limited only by associated circuitry	3 3/8" dia. x 6 3/4"	5 lbs., 6 oz.		4 oz-in	(1) Max. slew rate while counting: 100°/sec. (2) Absolute angle reading always present in the counter. (3) Re-establishes its absolute position with each degree. (4) Can be built for straight binary operation also. (5) Reads degrees to 0.001 degree.
					Part of system to convert micrometer lead screw shaft position to digital code on punched tape.
1800 rpm	2" x 3 1/2" x (4" to 5 1/2")	2 lbs. to 2 1/2 lbs.	0.002 to 0.004 lb-in^2	0.1 oz-in. static	Contact capacity one amp. Operate like mechanical counter. No relays in readout.
Unlimited by Digicon limited by recorder or readout equip.	1. 7" x 1. 9" x 1. 9"	6 oz.		0.25 oz-in.	High speed shaft input 2000 rpm for servo drive.
100 pulses/sec, and up	3 3/4" dia. x 6 1/2" length	80 oz.	125 gm-cm^2	0.5 oz-in starting	Optical unit. Designed for military applications. Built-in alignment cell permits field calibration.
100 pulses/sec, and up	3 3/4" x 6 1/2"	5 lbs.	125 gm-cm^2	0.5 oz-in.	Optical unit. Designed for military applications. Output words are sin and cos of input angle. Built-in alignment cell permits field calibration.
To 100,000/sec	2.3" dia. x 15/16" long	7 oz.	52 gm-cm^2	0.05 oz-in.	Available in other resolutions and with built-in buffer amplifier. Rotation of an optical interference pattern is sensed by push-pull photo circuit.
150 rpm	15/16" dia. x 1 15/32"	1.1 oz. approx.		0.2 oz-in	Miniature for airborne applications. No brush adjustments required.
150 rpm	15/16" dia. x 1 5/16"	1 oz. approx.		0.2 oz-in	Miniature for airborne applications. No brush adjustments required.
50 rpm	2 1/2" dia. x 2 19/32"	8 oz.		0.6 oz-in	Consists of 3 ganged 5-digit converters. No brush adjustments required.
Up to 35,000/sec, 20 microsec pulses	1.562" dia. x 1.920 long	3.1 oz.	0.078 oz-in^2	0.35 oz-in	Special patterns available. The standard instruments have a common terminal switched to separate terminals for each digit. Straight mechanical switching. No logic circuitry.
Up to 35,000/sec, 20 microsec pulses	3.00" dia. x 1.10" long	7 oz.	0.39 oz-in^2	0.8 oz-in	Same as for Type 15E-8.
Up to 35,000/sec, 20 microsec pulses	3.00" dia. x 1.10" long	7 oz.	0.39 oz-in^2	0.8 oz-in	Same as for Type 15E-8.

Summary of Physical and Performance

MANUFACTURER	MODEL	TYPE INPUT	VOLTAGE INPUT RANGE	TYPE READOUT	NUMBER SYSTEM	NUMBER OF DIGITS	ACCURACY
EPSCO, INC.	DVOM (DV-803)	d-c volts, a-c volts, resistance	±1, ±10, ±100, ±1000 volts; one ohm to a megohm	Serial, parallel	Decimal, binary coded decimal	3 decimal plus overflow digit	d-c volts 0.1%, a-c volts 0.25%
EPSCO, INC.	Datrac B-611	Voltage	±1, ±10, ±100 volts; specials on request	Serial, parallel	Binary	11 including sign	0.05%
EPSCO, INC.	Datrac B-613	Voltage	±1, ±10, ±100 volts	Serial, parallel	Binary coded decimal; 8,4,2,1 code	3 decimal plus sign	0.05%
EPSCO, INC.	Minidatrac SVD-610	Voltage	±10 v, ±5 v	Serial, parallel	Binary	10	±0.1%
EPSCO, INC.	Transicon Datra (many models)	Voltage	±10 v standard; others available	Serial, parallel	Binary, binary coded decimal; 8,4,2,1 code	Binary: 9 to 13 bits including sign; BCD: 3 decimal digits plus sign	±0.05% or 1 millivolt
FRANKLIN ELECTRONICS, INC.	1310N/319	Voltage	100 μv to 1000 v		Binary, binary coded decimal	4 decimal	0.1% to 0.05%
W. & L.E. GURLEY	8613	Shaft		Parallel	Gray	13	1 part in 16,384
HOOVER ELECTRONICS	10029	Voltage or current	±1 v, or 6 ma ± 4 ma	Parallel or serial	Binary	11 including sign	0.05% ± 1/2 absolute magnitude of least significant quantity
INSTRUMENT DEVELOPMENT LABS., INC.	500206	Shaft		Parallel	Binary coded decimal, non-ambiguous	4 decimal	1 part in 1000
INSTRUMENT DEVELOPMENT LABS., INC.	500216	Shaft		Parallel	Binary coded decimal, non-ambiguous	4 decimal	1 part in 3600 (0.1°)
INSTRUMENT DEVELOPMENT LABS., INC.	500217	Shaft		Parallel	Binary coded decimal, non-ambiguous	6 decimal	1 part in 216,000 (0.1')
KEARFOTT CO., INC.	423830-1	Shaft		Parallel or serial	Binary coded decimal	2 decimal	1 part in 85
KEARFOTT CO., INC.	423607-1	Shaft		Parallel or serial	Binary coded decimal	3 decimal including sign	1 part in 39
KEARFOTT CO., INC.	Y1241-11A	Shaft		Parallel or serial	Binary coded decimal	3 decimal	1 part in 360
KEARFOTT CO., INC.	Y1240-11A	Shaft		Parallel or serial	Binary coded decimal	4 decimal	1 part in 3600
KEARFOTT CO., INC.	P124-11A	Shaft		Parallel or serial	Binary coded decimal	4 decimal including sign	1 part in 2000
KEARFOTT CO., INC.	U1240-11	Shaft		Parallel or serial	Binary coded decimal	4 decimal	1 part in 3600
KEARFOTT CO., INC.	P1241-11A	Shaft		Parallel or serial	Gray	15	1 part in 32,768
LITTON INDUSTRIES	AD 11-13	Shaft		Parallel	Binary	13	1 part in 8192
LIBRASCOPE, INC.	707 and 707D	Shaft		Serial	Binary	7	1 part in 128
LIBRASCOPE, INC.	713 and 713D	Shaft		Serial	Binary	13	1 part in 8192
LIBRASCOPE, INC.	717 and 717D	Shaft		Serial	Binary	17	1 part in 131,072
LIBRASCOPE, INC.	719 and 719D	Shaft		Serial	Binary	19	1 part in 524,288
LIBRASCOPE, INC.	740	Shaft		Parallel	Binary	10	1 part in 1024
LIBRASCOPE, INC.	743	Shaft		Parallel	Binary	13	1 part in 8192
LIBRASCOPE, INC.	757	Shaft		Serial	Sin—cos binary	7/quadrant (4 quadrants)	1 part in 192
LIBRASCOPE, INC.	757-S	Shaft		Serial	Sin—cos binary	7/quadrant (4 quadrants)	1 part in 192
LIBRASCOPE, INC.	758	Shaft		Serial	Sin—cos binary	8/quadrant (4 quadrants)	1 part in 384

Characteristics of Analog-Digital Converters

SAMPLING RATE	SIZE	WEIGHT	INERTIA	FRICTIONAL TORQUE	SPECIAL FEATURES
100/sec max.	Portable: 6 1/8" x 8 3/4" x 13 1/8" Rack mounted: 5 3/4" x 19" x 12 3/4"	22 lbs. approx.			Many outputs. Transistorized. Conversion method is sweep counter. Model DV-803 is identical except that it measures d-c volts only.
44,000 max.	Converter: 15 3/4" x 19" x 18" Power unit: 10 1/2" x 19" x 18"	Converter: 67 lbs. Power unit: 89 lbs.			Many outputs. Conversion method is successive approximation. Absolute accuracy without calibrations or adjustments.
38,000 max.	Converter: 15 3/4" x 19" x 18" Power unit: 10 1/2" x 19" x 18"	Converter: 67 lbs. Power unit: 89 lbs.			Many outputs. Conversion method is successive approximation. Absolute accuracy without calibrations or adjustments.
25 kc max. 50,000 conversions/sec on request.	Converter: 2 11/16" x 6" x 22 3/4" Power unit: 2 3/4" x 6" x 22 3/4	Converter: 13 lbs., 8 oz. Power unit: 20 lbs.			Many outputs. Conversion method is successive approximation. Absolute accuracy without calibrations or adjustments.
Examples: 20 kc for 8 binary 14 kc for 12 binary	5 1/4" x 19" x 16"	25 lbs. approx.			Many outputs. Transistorized, reversible. Conversion method is successive approximation. Absolute accuracy with no calibrations or adjustments.
Up to 60 readings/sec	19" x 8 3/4" x 15"	50 lbs. approx.			Visual nixie readout, also for automatic logging, d-c input.
100/sec	3 1/2" dia. x 7 5/8"	5.6 lbs.	349 gm-cm^2	0.5 max. oz-in	Optical. Nonlin. and trig. functions available. Also BCD codes.
20 kc/sec					Visual neon indication. Reversible to digital-analog by different digital input plug connection. Current or voltage input determined by substitution of input modules.
20,000 bits/min (max.)	1.754" dia. x 2.125"	4.7 oz.	0.003 lb-in^2	0.3 oz-in (min.)	40 bits per shaft revolution. For servo-driven airborne systems. Bi-directional. Readout on demand.
20,000 bits/min (max.)	1.754" dia. x 2.375"	4.8 oz.	0.003 lb-in^2	0.3 oz-in (min.)	40 bits per shaft revolution. For servo-driven airborne systems. Bi-directional. Readout on demand.
20,000 bits/min (max.)	2.156" dia. x 2.375"	8 oz.	0.004 lb-in^2	0.3 oz-in (min.)	40 bits per shaft revolution. For servo-driven airborne systems. Readout on demand.
1100 rpm	2 1/8" dia. x 31/32"	5 oz.	158 gm-cm^2	0.5 oz-in static	1-drum unit.
250 rpm	1 3/4" dia. x 1 1/16"	3.5 oz.	48 gm-cm^2	0.1 oz-in static	1-drum unit.
300 rpm	1 15/16" dia. x 1 43/64"	5.75 oz.	104 gm-cm^2	1.0 oz-in static	2-drum unit.
300 rpm	1 15/16" dia. x 2 3/16"	7.75 oz.	158 gm-cm^2	1.0 oz-in static	3-drum unit.
400 rpm	1 7/16" dia. x 1 15/16"	4 oz.	28 gm-cm^2	0.5 oz-in static	3-drum unit.
700 rpm	1 7/8" dia. x 2 13/16"	6.5 oz.	100 gm-cm^2	1.0 oz-in static	4-drum unit.
600 rpm	1 7/16" dia. x 3"	5 oz.	20 gm-cm^2	2.0 oz-in static, 1.0 oz-in running	5-drum unit.
Depends on circuitry	1.062" dia. x 1.828"	2.4 oz.	0.01 oz-in^2	0.5 oz-in starting, 0.4 oz-in running	Miniature size combined with conservative reliability. V-scan.
	2" dia. x 2 49/64"	6 oz.	0.08 oz-in^2	0.4 oz-in	Contains isolation diodes for sequential multiplexing applications.
	2" dia. x 3 19/32"	8 oz.	0.08 oz-in^2	0.4 oz-in	Contains isolation diodes for sequential multiplexing applications.
	2" dia. x 4 13/16"	11 oz.	0.08 oz-in^2	0.4 oz-in	Contains isolation diodes for sequential multiplexing applications.
	2" dia. x 4 13/16"	11 oz.	0.08 oz-in^2	0.4 oz-in	Contains isolation diodes for sequential multiplexing applications.
	2 1/4" dia. x 4 3/16"	16 oz.	4.00 oz-in^2	0.5 oz-in	
	2" dia. x 3 19/32"	9 oz.	0.08 oz-in^2	0.4 oz-in	
	2 3/8" dia. x 4 11/64"	12 oz.		3.5 oz-in	Sine and cos presented simultaneously. The limit ℓ and quadrant information are available for each function.
	2 1/4" dia. x 5 1/4"	20 oz.			Servo-driven unit. Sine and cos presented simultaneously. The limit ℓ and quadrant information are available for each function.
	4 1/8" dia. x 3 9/16"	16 oz.	4.00 oz-in^2	7.0 oz-in	Sine and cos presented simultaneously. The limit ℓ and quadrant information are available for each function.

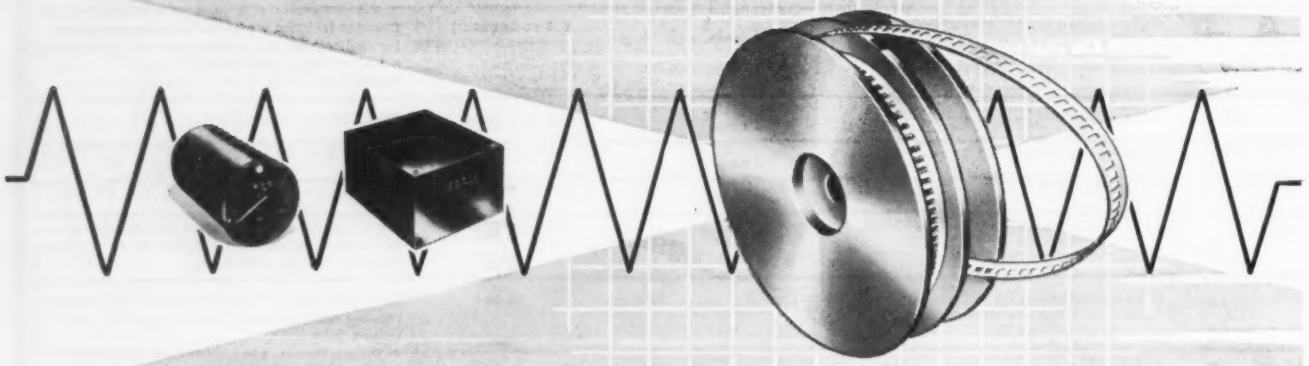
Summary of Physical and Performance

MANUFACTURER	MODEL	TYPE INPUT	VOLTAGE INPUT RANGE	TYPE READOUT	NUMBER SYSTEM	NUMBER OF DIGITS	ACCURACY
LIBRASCOPE, INC.	758-S	Shaft		Serial	Sin-cos binary	8/quadrant (4 quadrants)	1 part in 384
LIBRASCOPE, INC.	723 and 723D	Shaft		Serial	Binary coded decimal	4 decimal	1 part in 2000
LIBRASCOPE, INC.	724 and 724D	Shaft		Serial	Binary coded decimal	5 decimal	1 part in 20,000
LIBRASCOPE, INC.	733 and 733D	Shaft		Serial	Binary coded decimal	4 decimal	1 part in 3600
LIBRASCOPE, INC.	734 and 734D	Shaft		Serial	Binary coded decimal	5 decimal	1 part in 36,000
LIBRASCOPE, INC.	735	Shaft		Serial	Binary coded decimal	6 decimal	1 part in 360,000
F.L. MOSELEY CO.	20 C Voltmeter	Voltage	3 mv to 300 v		Decimal, binary coded decimal	3 decimal	±0.25% of full scale
NORDEN DIV., UNITED AIRCRAFT	ADC-ST 7-BNRY	Shaft		Serial or parallel	Binary	7	1 part in 128
NORDEN DIV., UNITED AIRCRAFT	ADC-ST 10-BNRY	Shaft		Serial or parallel	Binary	10	1 part in 1024
NORDEN DIV., UNITED AIRCRAFT	ADC-19-BNRY	Shaft		Serial or parallel	Binary	19	1 part in 524,288
NORDEN DIV., UNITED AIRCRAFT	ADC-ST 7-BNRY-X	Shaft		Serial or parallel	Binary	7	1 part in 128
NORDEN DIV., UNITED AIRCRAFT	ADC-19-BNRY-X	Shaft		Serial or parallel	Binary	19	1 part in 524,288
NORDEN DIV., UNITED AIRCRAFT	ADC-ST 9-Gray	Shaft		Serial or parallel	Gray	9	1 part in 512
NORDEN DIV., UNITED AIRCRAFT	ADC-ST 3-BCD	Shaft		Serial or parallel	Binary coded decimal	3 decimal	1 part in 1000
NORDEN DIV., UNITED AIRCRAFT	ADC-3-BCD	Shaft		Serial or parallel	Binary coded decimal	3 decimal	1 part in 1000
NORDEN DIV., UNITED AIRCRAFT	ADC-5-BCD	Shaft		Serial or parallel	Binary coded decimal	5 decimal	1 part in 100,000
NORDEN DIV., UNITED AIRCRAFT	ADC-ST 3-36 BCD	Shaft		Serial or parallel	Binary coded decimal	3 decimal	1 part in 360
NORDEN DIV., UNITED AIRCRAFT	ADC-5-36-BCD	Shaft		Serial or parallel	Binary coded decimal	5 decimal	1 part in 36,000
NORDEN DIV., UNITED AIRCRAFT	ADC-5-LNG-BCD	Shaft		Serial or parallel	Binary coded decimal	5 decimal	1 part in 36,000
NORDEN DIV., UNITED AIRCRAFT	BRL-5 (ST)	Shaft		Serial or parallel	Binary coded	5 decimal	1 part in 360,000
NORWOOD CONTROLS	Series 2100	Shaft		Parallel	Many codes	3 decimal	±1/4% over 300° rotation
SOUTHWESTERN INDUSTRIAL ELECTRONICS CO.	ADC-5	Voltage	a-c volts, 0 to 0.5; d-c current, 0 to 10 ma	Serial or parallel	Binary coded decimal	3 decimal	0.1%
TALLER & COOPER, INC.	DC 4	Shaft			Decimal	3 standard	0.1% standard
TELECHROME MFG. CORP.	TeleAD	Shaft		Parallel	Decimal, binary	6 decimal	To nearest unit count
WAYNE GEORGE CORPORATION	RD-13 B	Shaft		Parallel	Gray	13	1 part in 8192
WAYNE GEORGE CORPORATION	RD-8	Shaft		Parallel	Gray	8	1 part in 256
WAYNE GEORGE CORPORATION	RI-10	Shaft		Incremental		1024 counts per revolution	1 part in 1024
WEST COAST RESEARCH CORP.	To specifications	Voltage				2,3,4	As specified

Characteristics of Analog-Digital Converters

SAMPLING RATE	SIZE	WEIGHT	INERTIA	FRICTIONAL TORQUE	SPECIAL FEATURES
	4 1/8" dia. x 7 1/2"	30 oz.			Servo-driven unit. Sine and cos presented simultaneously. The limit ℓ and quadrant information are available for each function.
	3 1/16" dia. x 4 27/32"	22 oz.	1 oz-in^2	0.6 oz-in (max.)	Contains isolation diodes for sequential multiplexing applications. All four binary lines representing a decimal decade are available in parallel. Each decade is available in serial, lowest order first.
	3 1/16" dia. x 4 27/32"	22 oz.	1 oz-in^2	0.6 oz-in (max.)	Same as Type 723 and 723D.
	3 1/16" dia. x 4 27/32"	22 oz.	1 oz-in^2	0.6 oz-in (max.)	Same as Type 723 and 723D.
	3 1/16" dia. x 6 3/8"	31 oz.	1 oz-in^2	0.6 oz-in (max.)	Same as Type 723 and 723D.
	3 1/16" dia. x 6 3/8"	31 oz.	1 oz-in^2	0.6 oz-in (max.)	All four binary lines representing a decimal decade are available in parallel. Each decade is available in serial, lowest order first.
1 per second	7" rack panel unit	35 lbs. approx.			Readout is of the "on demand" type. Many outputs: punched card, perforated paper tape, IBM typewriter, lamp bank.
Limited by associated circuitry	1 3/4" x 1 3/4"	3.6 oz.	0.0495 oz-in^2	0.2 oz-in (max.)	Employs self-selecting V-brush logic with digit and complement both available. D-c or pulse output.
Limited by associated circuitry	2 3/8" x 6 7/32"	44 oz.	4800 gm-cm^2	6.0 oz-in (max.)	Employs self-selecting V-brush logic with digit and complement both available. D-c or pulse output.
Limited by associated circuitry	4 15/32" x 1 3/4"	10.4 oz.	0.0496 oz-in^2	0.2 oz-in (max.)	Employs self-selecting V-brush logic with digit and complement both available. D-c or pulse output.
Limited by associated circuitry	1 9/16" x 1 3/4"	3.4 oz.	0.0495 oz-in^2	0.2 oz-in (max.)	Employs V-disc in which V-scan technique is transferred from usual brush position to precision pattern on code disc. D-c or pulse output.
Limited by associated circuitry	3 31/64" x 1 3/4"	7.3 oz.	0.0496 oz-in^2	0.2 oz-in (max.)	Same as Type ADC-ST7-BNRY-X.
Limited by associated circuitry	1 29/32" x 2 1/4"	4.5 oz.	0.1677 oz-in^2	0.2 oz-in (max.)	D-c or pulse output.
Limited by associated circuitry	2 3/8" x 6 7/32"	44 oz.	4800 gm-cm^2	6.0 oz-in (max.)	Employs self-selecting V-brush logic with digit and complement both available. D-c or pulse output.
Lim. by assoc. circ.	3 17/64" x 2 1/4"	9.22 oz.	0.1716 oz-in^2	0.4 oz-in (max.)	Same as Type ADC-ST3-BCD.
Lim. by assoc. circ.	5 5/16" x 2 1/4"	16.65 oz.	0.1716 oz-in^2	0.4 oz-in (max.)	Same as Type ADC-ST3-BCD.
Lim. by assoc. circ.	1 11/16" x 3 1/4"	15 oz.	220 gm-cm^2	1.0 oz-in (max.)	Same as Type ADC-ST3-BCD.
Lim. by assoc. circ.	4 7/8" x 2 1/4"	13.20 oz.	0.1716 oz-in^2	0.4 oz-in (max.)	Same as Type ADC-ST3-BCD.
Limited by associated circuitry	7 5/64" x 2 1/4"	21 oz.	0.1716 oz-in^2	0.4 oz-in (max.)	Counts in degrees and hundredths of degrees longitude including sign in sequence plus 0.00 through plus 179.99 minus 180.00 through minus 0.01 plus 0.00 Employs self-selecting V-brush logic. D-c or pulse output.
Limited by associated circuitry	6.726" x 3.375"	5 lbs., 6 oz.	3210 gm-cm^2	3.5 oz-in (max.)	Highest resolution single turn encoder available; measures accurately to 3.6 seconds of arc. D-c or pulse output.
One readout/sec	4 7/8" x 5 1/8" x 2 5/16"	32 oz.	30 oz-in^2	0.5 oz-in (max.) starting	Printed disc separated from brushes during rotation, eliminates mechanical wear. Electrical wear removed because readout circuit is energized only after disc is in contact with brushes. Long life and high signal levels.
50 cps standard; faster rates in design					Transistorized.
9000 counts/min	3" x 4 1/2" x 2"	20 oz.		1 oz-in (max.)	
					Unique multi-drum unit. Separate switch for each bit. Readings on demand from integral memory. Outputs compatible with many devices.
To 100/second	3 19/32" dia. x 7 17/32"	6 lbs., 8 oz.	150 gm-cm^2 (max.)	0.5 oz-in (max.)	Optical unit. Designed to meet applicable portions of MIL-E-16400B. Shift register attachment to provide serial output is available.
To 100/second	3 19/32" x 4 5/32"	4.5 lbs. approx.	150 gm-cm^2 (max.)	0.5 oz-in (max.)	Optical unit. Designed for use alone or with Type RD-13B in two-speed system.
Continuous	2 15/16" dia. x 4 7/16" length	2.5 lbs. approx.	150 gm-cm^2	0.5 in-oz.	Optical unit. Outputs: Off--10 volts, On--2 volts.
As specified	As specified	As specified			Designed and built to specifications. Single- or multi-channel display and record systems. Various outputs: CRT, print, counter, tape.

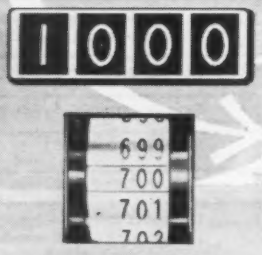
...*the instrument with the* TAPE-SLIDEWIRE!



Why not have

highest accuracy...

if it costs no more???



The basic accuracy of the Ta'Pot® results from its designed built-in correction for variations in wire diameter, structure or mechanical arrangement. Calibration is simply represented by punched holes in tape (for gearing to an in-line counter) or by printed scale markings on the tape. *B & H Instruments incorporating the Ta'Pot have a normal accuracy of 0.1% and higher accuracy is available.*

●

The TA'POT® is the fundamental component of these B & H Instruments:
AUTOTEMP™, AUTOTAK™,
MILLI-V-METER™,
JETCAL Analyzer®, TEMPCAL®

For particulars write or telephone (EDison 6-7243)...

NO MANUAL TAPPING or PADDING is PERFORMED or NECESSARY.

LOW COST and HIGH ACCURACY are the SIMPLE and NATURAL ATTRIBUTES of the DESIGN!

IT CANNOT BE MADE *LESS* ACCURATE!

TA'POT is the registered trade mark of Howell Instrument Company

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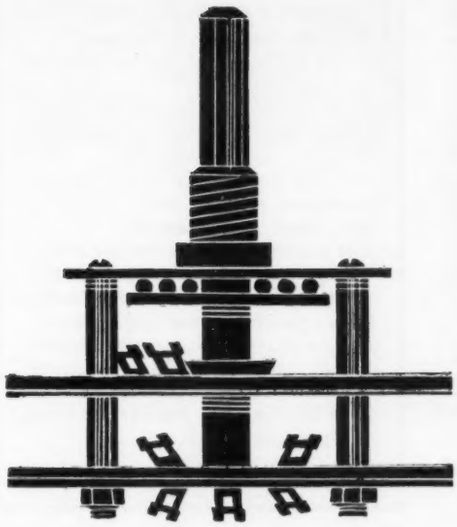

COMPONENTS DIGEST 8

Electromechanical Switches Part 1

Switches are devices that open and close electric circuits in a variety of sequences and combinations. Because of the importance of the switching function in regulation and control, the variety of switches available to suit different applications is tremendous. Switches are closely allied to relays, which are in reality electromagnetically actuated switches. Relays were described in Components Digest 5, and many of the principles covered, particularly in connection with contact ratings, are of interest in switch selection. Because of this previous coverage, relay-like devices are not considered in this Digest.

Requirements of extreme reliability, compactness, very high switching speeds, low power handling capacity and resistance to difficult environments has led to the development of switching devices of an esentially non-mechanical nature. These switching devices are based primarily upon semiconducting elements, such as diodes and transistors, used either individually or in special circuits as well as many newer types of semi-conductor elements. Vacuum tube circuits, such as flip-flops, gas-tubes, magnetic cores, and certain types of nonlinear resonant circuit also provide switching. Gas tubes and semi-conductors have been used in chopper circuits to provide long life at high switching speeds. Similar devices are particularly important in digital computer applications.

The principal deficiencies in these switches are:

- Relatively low power handling capacity.
- Imperfect switching action, comparable to a high contact resistance, or a low dielectric resistance in a conventional mechanical switch.

Notwithstanding these non-ideal performance features, the resistance ratios at open and short circuit can be extremely high, and quite usable in low power level circuits. In particular, applications to binary circuits present no problem.

Because of the broad field which may be encompassed under the heading of *switching devices*, this Components Digest will be limited to mechanically actuated switches. Even this more limited class includes such a variety that the mere process of describing the principal types becomes a difficult task. Therefore, here and in part II we shall confine our considerations to a broad description of the field of mechanical switches and pursue specific types in greater detail in Supplements that will be published from time to time.

SWITCH SELECTION PROCEDURES

Because they may be used in so many different ways, it is important to consider many performance factors before making a selection. Table I lists these factors compactly, describing each in considerable detail. Table II presents a concise step-by-step procedure for switch selection as recommended by Electro-Switch Corp. Of course, an intelligent selection requires a broad knowledge of available types and their individual characteristics. Such information is provided under the individual switch descriptions presented below and must supplement the more general viewpoint of Tables I and II.

Similarly, Table III tabulates environmental factors in switch selection while specific details regarding standard environmental tests and requirements, as governed by recognized specifications, are summarized after the descriptions of individual switch types are concluded in Part II.

SWITCH CONTACTS

Because of their special importance to all types of switching devices, the subject of contacts requires particular consideration. The following material derived from information provided by Micro Switch is a valuable introduction to this subject.

To understand the fundamentals of contact resistance, it is necessary first to look at the physical and electrical phenomena that occur when two contact points with a potential difference between them, close or open a circuit. When a potential exists between two contacts of a switch, and the circuit is to be closed, the distance between the contacts is decreased until the applied voltage causes an electrostatic failure of the gap. At this point an electron flow between the contacts is initiated, accompanied by a heating of

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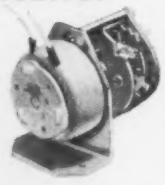

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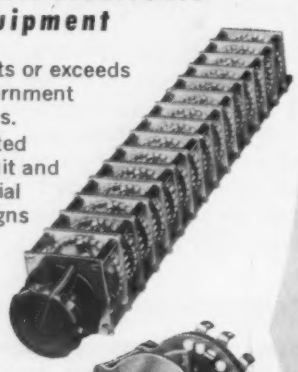

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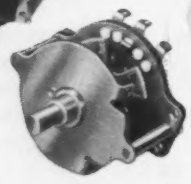

CAM SWITCHES
for counting and control
- Decade switch
- Control switch
- Decimal to binary converter

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COMPONENTS DIGEST

the cathode and cooling of the anode in accordance with the Thompson effect. The contact material melts and establishes a continuous metallic path, thus making the contact.

The "apparent" contact surface, which is the entire bearing area of the contacts, does not truly represent the "actual" amount of contact area. This "actual" surface is the minute area within the "apparent" surface that is subject to the highest pressure, and which is proportional in size to the applied pressure. The actual contact, then, is made between two molecular layers separated by a film of gas or other alien substance. Should the contact within the "actual" contact surface be nothing except the molecular contact material, then the condition known as "cold weld" exists.

There are two basic methods of mechanically accomplishing the closing of electrical contacts: the wiping action, and the striking action. Each method has certain physical characteristics that must be considered to complete the understanding of contact action.

In the case of the wiping action, the closing process does not consist of a smooth action, but proceeds as a series of jerks in which the contacts weld and then break loose, allowing the contacts to slip and giving the illusion of a wiping action. This action occurs even when the contacts are not carrying sizable currents.

In the case of the striking contacts, each contact is actually deformed by the impact. This deformation can either be elastic, in which the contact returns to its original shape after the removal of the pressure, or plastic, in which the contact does not regain its original dimensions. Most designers, however, have been able to overcome plastic deformation by studying the way in which the action takes place. For the purpose of this discussion, it is assumed that the switching device is going to be within its range of current carrying capacity, and not seriously overloaded.

CONTACT RESISTANCE

Contact resistance is a measure of the amount of energy dissipated between two conducting materials in touch with each other when a current flows between them. Contact resistance may also be described as a measure of the difficulty encountered by electrons in trying to move between two conducting materials in touch with each other. This type of resistance consists of three components: resistance of the contact material, resistance of the constriction, and resistance of the film. Of these components, the material resistance of the contacts themselves may be neglected as it represents such a small portion of the total.

TABLE II

Step-by-Step Procedures In Switch Selection

Sketch the circuit to show what switch must do.
What kind of load is to be handled—heater, lamp, transformer, motor; if inductive, give power factor.
Will the switch work under unusual conditions of heat, moisture, vibration, shock, or altitude?
List the electrical and mechanical requirements, such as: current rating, voltage, a-c or d-c, number of poles, throws, positions, panel or base mounting, panel thickness and shaft length.
Specify snap-action, detent-action, or momentary-contact (spring return).
Type of contacts—make-before-break or break-before-make.

SUGGESTED BY ELECTRO SWITCH CORP.

Constriction resistance is caused by the fact that the actual contact surface is extremely small in comparison with the electrically conducting portion. Regardless of surface preparation, there are always minute "high spots" which are the actual points of contact. Lines of current flow are bent together through these narrow areas, causing increased resistance called constriction resistance. This resistance is dependent upon the following factors: contact material, shape of the contacts, condition of the contact surface and mechanical pressure holding the contacts together.

As a general rule, constriction resistance will be higher for a smooth contact surface due to the relatively few actual contact points, than a slightly rough one.

Common films responsible for film resistance are the oxides, sulfides, complex sulfates, and chlorinates of the contact material. In addition of course are physical impurities, such as water or oil vapor, dust, dirt and other contaminants that occur in the surrounding atmosphere. Some of these films have low electrical resistance, while others have remarkably high dielectric strength and in some cases serve to prevent current flow until the voltage is high enough to rupture the film.

In the design of switching devices the following points may prove to be of assistance in minimizing contact resistance.

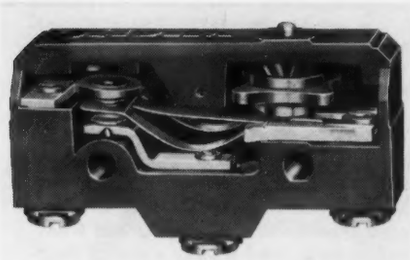

Fig. 1 Pin plunger basic switch showing movable serrated contact on spring and smooth stationary contact. Photo Courtesy of MICRO SWITCH.

Fig. 2 Toggle switch by Electro Snap.

Contact Material: Almost complete resistance to tarnishing and oxidation is found in platinum, palladium, gold, and certain of their alloys.

Contact Design: Knurling of the stationary contact and serration of the moveable contact helps to increase unit pressure, break through alien films and provide an escape for extraneous dirt.

Contact Action: Moderately high contact forces combined with a sliding or wiping action is very desirable because they tend to make maximum use of the knurling and serration in breaking through films. In addition the growth of heavy oxide film is retarded by the higher contact force.

Other Considerations: Care should be exercised to prevent the rubbing of insulating parts against metal with the resulting generation of dust. Tight enclosures to minimize the entry of foreign matter is of the utmost importance in the reduction of switching difficulties.

TYPES OF SWITCHES

Switches may be broadly classified by generalized function:

- Control – to power a circuit or electrical device
- Limiting – to regulate the motion limits of moving members, such as in selector switches, and other types. Each type is described; examples and typical machine tools
- Safety – to cut out a circuit under

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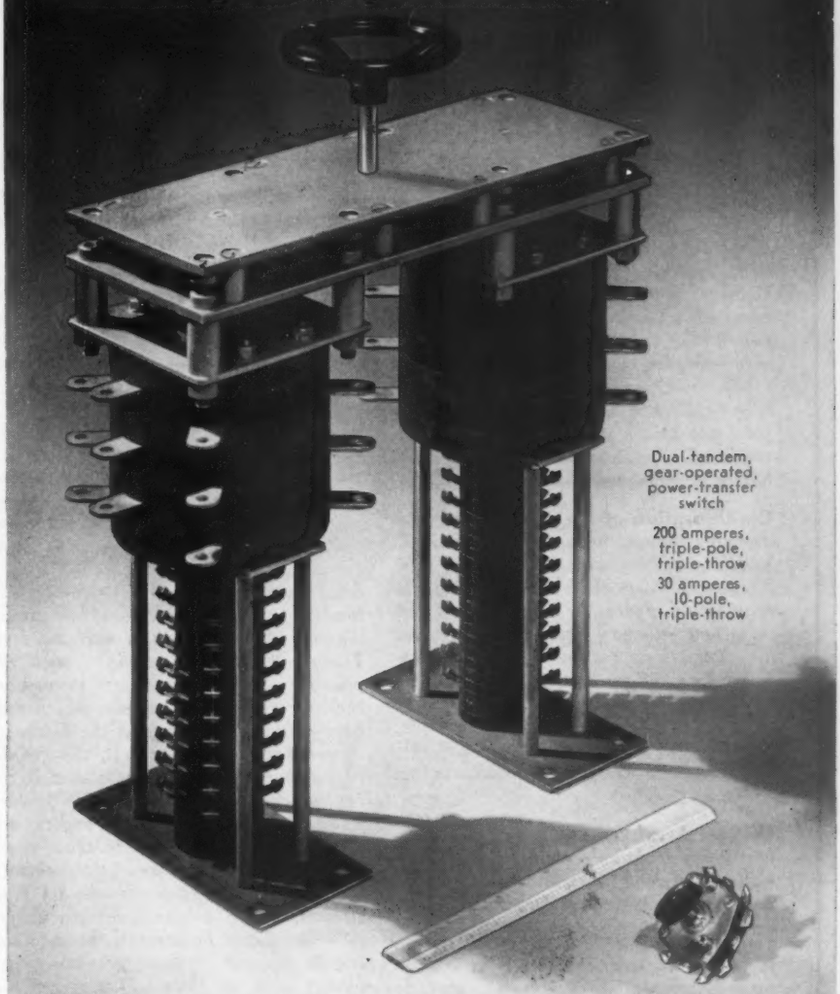

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TABLE I—
Switch Selection Factors

Type of Switch *is certainly the most important single decision in choosing a switch. The varieties are so great that a general acquaintance with the more important ones, as well as experience, are necessary in making an optimum selection. Whether the switch is to be snap-acting or not depends upon the type of switch required, its capacity, and the manner of use. Large knife-blade switches provide excellent self-cleaning and large current handling capacities. However, untrained personnel can wreak havoc with such switches by improper opening and closing techniques. In many applications requiring low torque, or precise switching angles, printed circuit switches are not snap-acting, nor are many other type switches designed for light operating forces. In other cases, however, because of the precise and pre-adjusted transit times, the snap-acting switch is to be preferred.*

In complex, low-power electronic circuitry, rotary selector switches, which may be stacked to provide a great many poles and switch positions, are commonly employed. Toggle switches are the work horses of input and power circuitry.

Configuration *of the switch, related to available space, mounting dimensions, handling of the actuating element, type of connections to the switch, and aspects relating to ruggedness and safety, is an important selection factor. Some switches are distinctively marked, include suggestive colors and perhaps pilot lights indicating "on" and "off". Sub-assemblies of groups of switches as, for example, push-button assemblies form attractive and compact items for installation in equipment.*

Contact Arrangement *is determined by how many separate circuits must be controlled and how many individual switch positions are required for each circuit.*

Contact Rating *involves a variety of factors: Voltage and current which must be interrupted; in-rush current; altitude requirements; a-c, d-c, High frequency; continuous current ratings; temperature rise within switch due to ohmic drop across contacts; heat dissipation at contact; physical sizes of contacts; ohmic or inductive loads.*

Lamp load ratings are of the order of a quarter of the rating for a resistive load, while motor ratings may be as low as one tenth the rating for a resistive load. Inductive loads require derating due to the tendency to maintain an arc on breaking the circuit. Capacitor loads also cause heavy inrush current. In general, d-c loads are more severe than a-c loads. As contacts are being separated, the a-c will, at some instant, pass through zero and the arc will be extinguished. An a-c circuit will also open at an average current less than peak current.

D-c currents introduce polarization effects which hasten the deterioration of the contacts. Contacts must be derated at high ambient temperatures.

The speed of make and break is an important factor in setting the rating of a switch. A high-speed "make" is desirable to minimize the duration of arc which forms as the contacts approach one another. A somewhat slower "break" action reduces the heavy transients which arise in d-c and inductive circuits and, to a lesser extent, in a-c current.

Contact Cleaning *is important since corrosion and contact pitting are normal occurrences. Simple push-buttons may actuate contacts by direct pressure in very low-level circuits, but where appreciable life, or high electrical ratings are required, some sort of self-cleaning action is indicated.*

Self-cleaning action is achieved by having the contacts slide over one another during switch operation. Knife-blade action provides excellent self-cleaning but is difficult to incorporate in miniature contact elements. Over-travel after contact engagement may automatically cause a sliding action to develop between a pair of closing contacts.

Switching Sequences *are an important switch selection factor. During the interval in which a switch is changing its condition, circuit conditions of some complexity may occur. For example, in multipole switches, it may be assumed that opening and closing the separate contacts cannot occur with perfect simultaneity. Upon examination of the circuit diagram, the possibilities may be seen. There may be, for example, such unpleasant circumstances as momentary shorting of a power supply, which may have a finite recovery time, the discharge of a condenser storage unit, the generation of pulses or false counts in a digital control circuit and other design factors. The variety of possibilities is endless and attention should be paid to these possibilities when intervals of less than a milli-second are encountered. In most circuits, where a significant amount of inductance may be present, the inductive lag in current changes prevents possibilities such as these. Similar remarks apply to the subject of contact bounce, especially in the reduction of contact life, the accentuation of radio interference and the errors which might be introduced in digital computer circuitry.*

Snap-acting switches attempt to minimize transit time and bounce. Many of the problems indicated above are handled by selecting switches which make and break contacts in a predetermined sequence. The make-before-break type is a common example, where a pole of a double throw switch is connected to the second circuit before it has broken contact with the first. Other sequences are also possible.

Insulation Resistance *is important in high impedance circuits, especially those where precise computations are performed. For example, a summation resistor of 1 megohm would be seriously effected by a parallel 10 megohm resistance to ground. Low insulation resistance in a high voltage circuit may result in excessive dissipation within the dielectric leading to ultimate failure. For applications where arc-over is a problem, the insulation material should be selected so as not to form a conducting surface film. Such a film may build up after repeated arcs on making and breaking contacts, and lead to eventual flash-over. Barriers placed between high voltage points can reduce this type of difficulty. Insulation resistance is particularly a problem after humidity tests when the dielectric has had an opportunity to absorb water, and surface films of moisture may be present.*

Switches intended for use in high frequency circuits should be checked for stray capacitance. In certain applications, even a few microfarads are important.

Radio Interference *of switches should be checked. Arcing at switch contacts causes electrical noise covering a wide frequency spectrum, which may interfere with communications equipment in the vicinity. The frequency and circumstances of throwing the switch determine whether arc suppression circuits are indicated.*

Safety Features *are often covered by standard specifications. The switch housing and any metal portion emerging, other than the terminals, should not be "hot". The mechanism should not crack or otherwise become defective as a result of the normal handling encountered in actual use. Replacement should be simple. Danger should not be introduced to the operator as a result of environmental conditions which may short-circuit or ground normally isolated portion of the frame.*

Standard Specifications *involve various groups, such as agencies of the Armed Services, Underwriters Laboratory, JIC and ASA. They have prepared standard performance and evaluation specifications for the common types of switches. However, because of the variety of switches, these specifications are far from inclusive but nevertheless serve as guides in the preparation of new specifications. Some standards go to great length specifying such design features as minimum internal creepage distance, for example, and switches meeting these standards may be relied upon to deliver rated performance with an ample safety factor, as long as they are properly used.*

Environmental Factors *are considered in more detail in Table II. Switches for the Armed Services must generally meet the same environmental specifications as other component parts, typically MIL-E-5272, (See Components Digest 4, Environmental Testing). Because they are used in so many different places, in both military and industrial installations, switch requirements may include just about any of the environmental requirements of related equipment, including neutron radiation, and extremely high temperature, for example.*

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abnormal conditions where safety to operator or equipment may become a problem.

Additional classifications may be based upon power handling capacity, ranging from negligible (in electronic circuitry) to thousands of kilowatts in big power station switch gear.

In this Components Digest, switches are broken down by type, based upon their construction and physical configuration such as toggle switches, rotary specifications, as well as suggested applications are given. Although specialized types are too numerous to be listed completely, Table IV tabulates the more important ones.

In addition to the usual selection factors of performance, size, ruggedness and price, human factors must be given adequate attention since switches are usually hand operated. Hand operation accounts, to a large extent, for innumerable variations. Safety, type of mounting, ease of manipulation, ruggedness and shape of the actuating member are some of the "human factors" to be considered in selection.

Toggle Switches

Toggle switches are low-cost, widely used, snap-acting switches which are actuated by motion of a toggle lever, (Fig. 2). These switches, properly applied, can give long life for the different kinds of power loads they are rated to handle. When used under highly specialized conditions for which manufacturers information is not available, as for example in high frequency

TABLE III—Environmental Factors In Switch Performance

Temperature: *Switch must withstand ambient temperature + temperature rise of equipment + temperature rise within the switch itself. Latter rise is signficant when switch must carry sustained heavy currents. Dimensional stability affecting, for example, contact spacing, insulation properties of the dielectrics and spring characteristics all are affected by temperature. Corrosion of contacts is accelerated at high temperature.*

Differential expansion, particularly where dielectric and metal are rigidly joined, may introduce excessive stresses leading to cracks at low temperature, permitting entrance of moisture or other foreign matter and finally to voltage breakdown. Unequal expansion of parts may lead to binding of the switch making it impossible to operate. Temperature shock emphasizes the strains of differential expansion as a result of transient temperature differences, its principal effect being the development of cracks. Changing temperatures encourage moisture condensation within the switch with its inherent harmful effects.

Altitude: *Altitude affects flashover between points having a difference of electrical potential, and, as a result, is of vital importance in establishing the correct voltage ratings of a switch. Because of the importance of spacing, flashover is most significant in subminiature devices. Because arcing is more severe at high altitudes, contact damage on opening and closing of cicuits is accentuated, indicating a reduction in current as well as voltage rating. Relations between rating and altitude have been previously treated in Components Digest 5, on Sensitive Relays. Moisture, oil, or other fareign substances in the atmosphere also require a reduction in rating.*

Humidity and Salt Spray: *Moisture accelerates corrosion, particularly where dissimilar metals are in contact. A film of moisture across a dielectric surface acts as a parallel conduction path, and can lead to voltage breakdown. A reduction in insulation resistance of the dielectric is caused by its absorption of water.*

Entry of moisture in a switch can be reduced by such standard techniques as sealing or waterproofing hermetically sealed switches being available for critical requirements. Humidity tests are described in MIL-E-5272, and MIL-STD-202, as well as other specifications, see Components Digest 4 on Environmental Testing.

Salt spray, or operation in a salt-laden atmosphere, introduces corrosion problems which may be more severe than those caused by humidity. However, it is easier to seal out salt than moisture.

In addition to its corrosive effects, salt deposits may interfere with the mechanical operation of the switch, preventing proper contact closing. Salt deposits lower breakdown voltage and arc resistance.

To minimize salt spray damage, direct contact of dissimilar metals as classified in Application Design Note ADN-10878 should be avoided, and exposed surfaces of corrodable metals should be suitably protected. Plating, painting, anodizing operations, provide suitable finishes for many metals and the use of inherently corrosion-resistant materials, such as passivated stainless steel, and the noble metals, is recommended. Fortunately, a great variety of excellent contact materials are inherently corrosion resistant. Components Digest 4 on Environmental Tests describes salt-spray tests covered by the important military specifications. Federal Specification QQ-M-151, "Metals; General Specification for Inspection of," describes a salt spray test in detail.

Vibration, Shock and Acceleration: *Vibration may cause the contact arm to chatter, or introduce resonances leading, perhaps, to fatigure failure in the switch elements. Chatter can cause arcing as the contacts approach one another, intermittent contact, and the generation of radio noise. In application, the transmission of vibrational energy at the resonant frequencies of the contact arm must be avoided. As in all vibration tests, the structure supporting the element under test exerts a major effect on its resistance to vibration.*

Shock may introduce structural damage, contact bounce, arcing and electrical noise. The nature of the shocks to be anticipated in use, as well as the effects of intermittent contact behaviour during shock, are important factors in preparing a shock requirement for a switch.

Acceleration is related to shock except in that it generally is more sustained and of lesser amplitude. Structural rigidity, as well as proper functioning of the contacts in all directions of acceleration are the important performance factors. Combined acceleration and vibration or shock may result in improper functioning even though the INDIVIDUAL *tests are successfully met. For example, the deflection of a contact spring under acceleration may lead to malfunctioning when vibration deflections are added. Random vibration and acoustic noise tests are becoming more important in the simulation of missile environments and tests requirements of these types may have to be included in the environmental specifications for a switch. ADDITIONAL ENVIRONMENTAL REQUIREMENTS: Explosion resistance requires switch operation in a voltable atmosphere without causing an explosion. Because of sparking during contact opening or closing, this requirement may be difficult to meet except in hermetically sealed units.*

Sand and dust interfere with the proper mechanical functioning of the switch, jamming the elements, and preventing proper closing of the contacts, as well as introducing abrasive wear.

Fungus problems are best avoided by using non-nutrient materials, and the minimization of internal moisture by some sort of sealing.

Combined Environments: *Combined environments, dealt with in Components Digest 4, on Environmental Testing, introduces problems which may be non-existent during the individual environmental tests described above. Temperature and altitude, and temperature and vibration, are the commonest combined environmental conditions under which difficulties might be anticipated. The choice of natural combinations which may lead to particularly severe conditions must be made on the basis of the actual conditions anticipated in practice.*

GROUND SUPPORT EQUIPMENT

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Inertial Guidance System Test Console

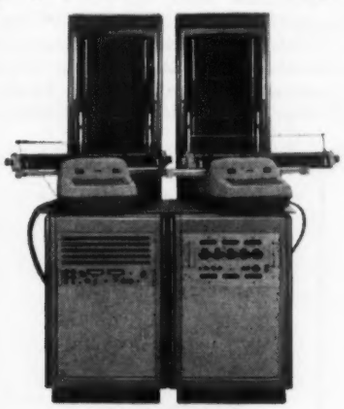
IN-PLANT TEST EQUIPMENT: Rack-mounted modules comprise the necessary metering circuits, signal generators and power supplies, switching circuits and junction boxes to perform the following tests on inertial reference systems:

Voltage and phase • Current • Heating cycle checks • Verticality of platform in ground erection mode • First order erection time in ground erection mode • Measurements of platform roll and pitch output angles in ground erection mode • Measurements of free drift of platform in azimuth in ground erection mode • Measurement of azimuth gyro torquer scale factor in ground erection mode

FIELD-TYPE TEST EQUIPMENT: Modularized, self-contained unit that provides all power and signal voltages to operate, test or trouble-shoot a gyro. All inputs to and outputs from the gyro are accessible at convenient jacks where connections to measuring equipment can be made, thereby enabling operator to evaluate gyro performance completely. Modules are slide-mounted for ready access if repair, modification or product improvement replacement are required. This portable equipment performs these basic tests:

Insulation resistance • Warm-up time • Torquer scale factor measurement Gyro transfer function • Free drift • Gimbal offset drift • Continuity Signal Generator Null • Phasing • Gyro drift • Fixed torque restraint

Floated Gyro Test Console



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Write for complete information on Kearfott's ground support equipment.

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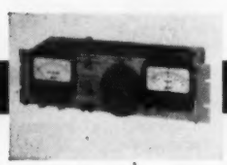

VTVM-PSVM

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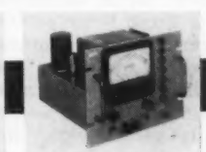
Precise Angle
Indicator Module



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circuits where switch capacitance is important, it may be necessary to pin down additional design features beyond those normally specified. Two and three position toggle switches and special 4-position types are available (Fig. 3). Toggle switches are covered by MIL-S-3950, and MIL-S-6745, as well as additional specifications of individual government agencies. Switch design and performance standards have been issued by non-military groups for commercial applications. Military Standards (MS) numbers have been assigned to many specific configurations. Approved suppliers of MIL-S-6745 switches are listed in Air Force-Navy Aeronautical Bulletin ANA-160. The subject of standards and specifications is presented much more fully in Part II of this Digest.

Current capacities in a-c toggle switch applications range in the vicinity

TABLE IV

Principal Types of Switches

- Toggle switches
- Push-button switches
- Microswitches
- Rotary selector switches
- Mercury switches, tilt-type
- Proximity switches
- Limit switches
- Pulsing switches
- Door interlock switches
- Open knife switches
- Enclosed, or safety switches
- Oil break switches
- Automatic switches
- Float operated switches
- Thermal switches
- Pressure switches

TABLE V

Typical Switch Ratings Under Different Load Conditions

CURRENT CAPACITY (AMPS)									
Continuous	Resistive Load					Lamp Load		Inductive Load	
	30 vdc	125 vdc	250 vdc	115 vac	230 vac	30 vdc	125 vac	30 vdc	125 vdc
55	25	0.75	0.5	20	7.5	7	7	20	15
55	20	0.75	0.5	20	7.5	5	4	18	11

Fig. 3 Subminiature four-way toggle switch mounts, in less than 2⅜ inch square. The Unimax Type 8SB2-1 combines the advantages of multi-circuit control, singlehole panel-mounting, and a toggle actuator, with subminiature size. Assembly consists of eight Unimax Type USM5 switches, secured in a mounting bracket, with a four-way toggle mechanism. The 15/32-32 threaded bushing permits single-hole mounting in panels pu to ¼ inch thick. Toggle is maintained in center position and is spring-returned from each of the four possible "operate" positions. Each "operate" position actuates two single-pole, double-throw switches. Eight basic switches contained in this unit meet Specification MIL-S-6743 and Military Drawing MS-25085-1. Electrical ratings of each basic switch are: 2.5 amperes, 30 volts d-c, inductive; 5 amperes, 30 volts, d-c, resistive; 5 amperes 125/250 volts a-c.

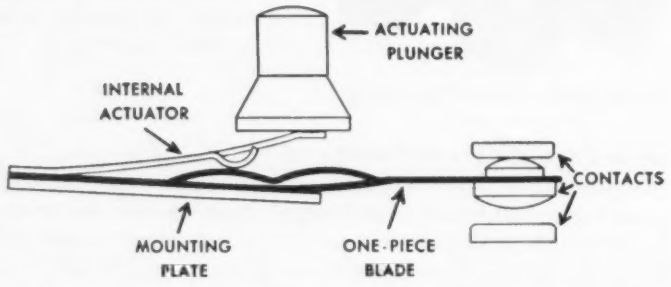

Fig. 4 Snap-action switches derive their snap-action from a one-piece main blade. This slotted bi-positional piece is prestressed by heat treating so that the center member is compressed and the two outside members are under tension. Depressing the actuating plunger forces the internal actuator against the two outside members of the main blade. The relationship between the members is thereby changed, and the blade snaps from the normal position to a second positive position. When the actuating plunger is released, a bias in the blade returns it to the normal position. Advantages: • High contact pressures result in excellent resistance to vibration. • Fast transfer time limits arcing and increases load capacity. • Variety of operating forces obtainable by varying thickness of blade. • Good repeatability, due to only one moving part. • One-piece precision tumbled blade has no wear points and provides long mechanical life.

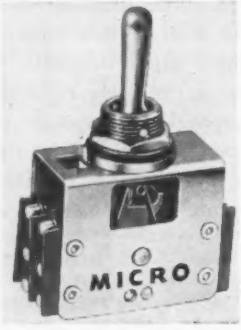

Fig. 6 The three functional switches operate at three lever positions: maintained, center, and momentary from each extreme position. Two of the switches are actuated when the lever is moved to one extreme position and the other switch is actuated in the other extreme position. Basic switch which is used for the "electrical memory" is actuated (maintained) in the other extreme position. Lever returning to the center position does not affect the memory switch, which indicates the extreme position in which the lever is in or was in most recently.

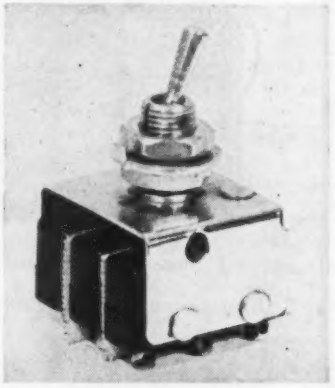

Fig. 5 Three-pole, double-throw unit is made up of 3 Electro-Snap sub-miniature switches and an actuator.

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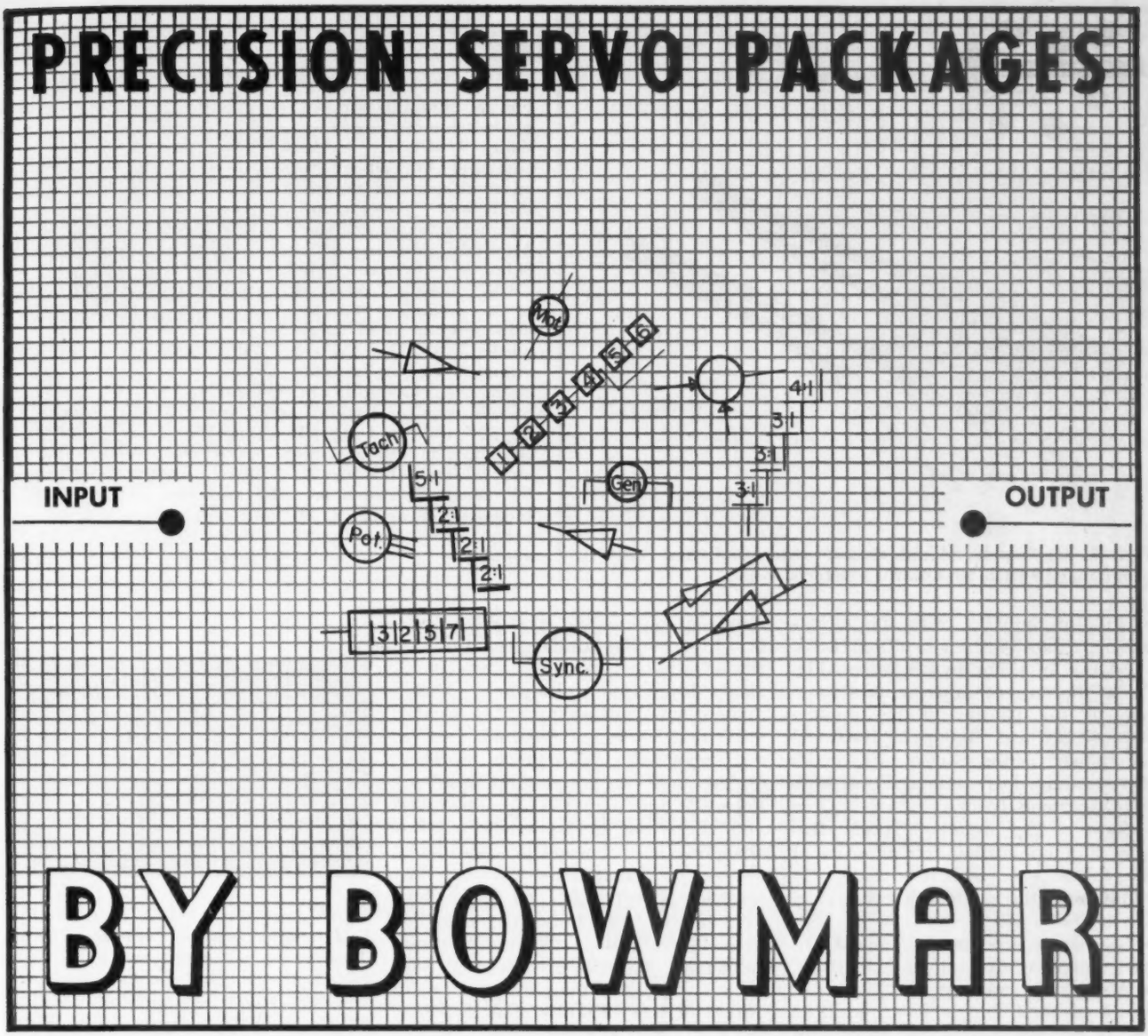

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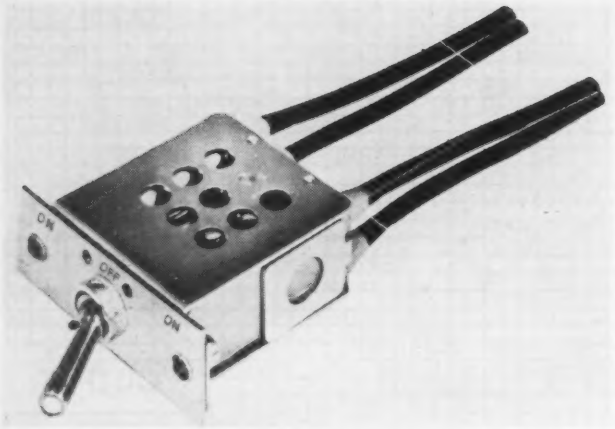

Fig. 7 Sing'e-pole, double-throw, waterproof and dust-proof togge switch by Control Products, Inc.

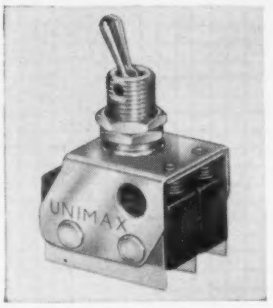

Fig. 8 Subminiature toggle switch mounting in less than 9/16-inch square, combines the advantages of doub'e-circuit control, single-hole panel-mounting and a toggle actuator. Assembly consists of a pair of Unimax Type USM5 switches, secured in a mounting bracket with a two-position toggle mechanism. The ¼"-40 threaded bushing permits single-hole mounting in panels up to ¼" thick. Switch requires back-of panel space 25/32" long x 21/32" wide and 21/32" deep. Two basic switches contained in this unit meet Specification MIL-S-6743 and Mi'itary Drawing MS-25085-1. Electrical ratings of each basic switch are: 2.5 amperes, 30 volts d-c, inductive; 5 amperes, 30 volts d-c, resistive; 5 amperes, 125/250 volts a-c, single-pole, doub'e-throw action.

of 10's of amperes, with d-c ratings but a fraction of the a-c rating. Table V relating to Micro Switch Series 31TS shows the current capacity as a function of the natures of the applied voltage and load. Ratings in fractional horsepower motor circuits are analogous to lamp load ratings where high inrush currents occur.

Some of the important special features and application requirements of the toggle type switch include, (in addition to the general selection factors of Table I):

- Sealed construction to prevent entrance of moisture and foreign matter.
- Ability to make or break circuits in all of three toggle lever positions (made possible by the *combination* of double-throw basic switching units in each switch).
- Momentary switches, which maintain a position only as long as the toggle lever is held, otherwise returning to a neutral or other fixed position. Combinations of momentary and detented positions are available.
- Snap action, which provides controlled rates for the opening and closing of electrical circuits, ideal for a-c applications where a relatively low speed is optimum for breaking a circuit. See Fig. 4 for a description of the snap-acting principle on a Haydon switch. A snap-acting toggle switch designed for a-c may have to be heavily derated for use in d-c circuits.
- Jumpers may be provided across some of the switch terminals for suitable applications.
- Multiple unit toggle assemblies are available for switching a number of separate toggle switches with a single lever, (Fig. 5). Such assemblies feature compact design, simplified mountings and considerable versatility. From four to twelve single-pole, double-throw switches may be thrown by a single lever. In a design by Micro Switch, simultaneous operation of the basic switches is not required.
- Hermetically sealed toggle switches are available for aircraft applications. Because they are sealed, performance and characteristics are unaffected by changes in atmospheric pressure, changes in temperature, corrosive atmosphere, dust, dirt, oil or water. The sealed vapor-proof character of hermetically sealed switches prevents formation of condensation on the switch contacts, permitting a wide variety of uses for which other switches are unsuitable. These switches also can meet the 50-hour salt spray test QQ-M-151.
- Miniaturized versions of most common toggle switches are available, where space is at a premium.
- "Electrical Memory" toggle switch, such as introduced by Micro Switch, uses one pole of its four pole circuitry to indicate which circuit was last operated (Fig. 6). This switch assembly employs three single-pole, double-throw "memory" switch that indicates through a pilot light or buzzer which circuit was last actuated.

Figs. 7 through 9 show and describe some of the many variations of toggle switch design for special applications.

Rotary Selector Switches

Rotary selector switches are an extremely flexible variety of switch for handling a great many connections. The basic contact arrangement may be expressed by the number of poles

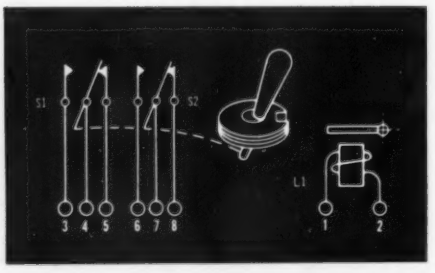

Fig. 9 Lear series 1472, *magnetically-he!d* toggle switches are specifically designed to withstand unusually high vibration and "g" loading and are qualified under the vibration requirements of MIL-E-5272A. These units perform under the most severe environmental conditions and wi'l retain their automatic-disconnet reliability in vibration frequencies up to 500 cps at 10 g's, providing positive circuit control whether manual or remote. Available in single-pole and double-pole models, Series 1472 Switches fit standard single-ho'e mountings per JAN provisions. They eliminate the necessity of "on-off" warning lights, and, unlike conventional designs, retain the natural feel of toggleswitch operation. Unusually light and compactly-packaged, the units incorporate a fail-safe feature which prevents the solenoid from pulling the switch closed, so that they may be armed in no other manner but manua'ly. They may be disarmed manually at any time, and they are automatically disarmed when the energizing voltage drops below five volts. Errors of circuit continuity which ordinarily result from residual magnetic fields after a power failure have been effectively eliminated by the Series 1472. Simplicity of design and incorporation of balanced components assure a long operating life in a corrosion-resistant package weighing only 0.25 pounds.

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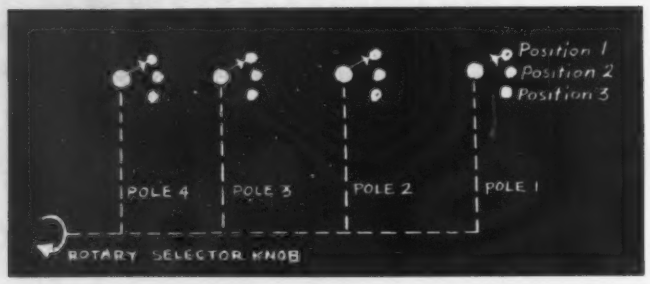

Fig. 10 Schematic of 4-pole, 3-position, rotary selector switch.

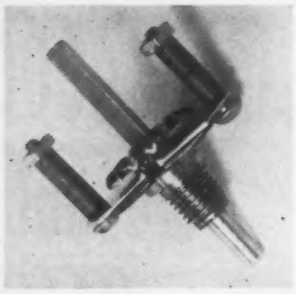

Fig. 13(a) Detent assembly of rotary selector switch by International Inst., Inc.

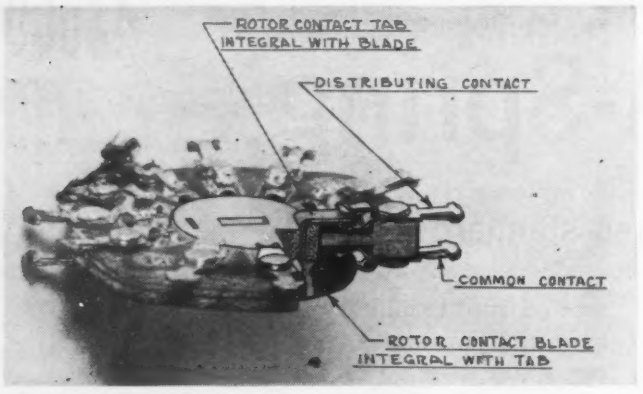

Fig. 13(b) Contact design of rotary selector switch by International Inst., Inc.

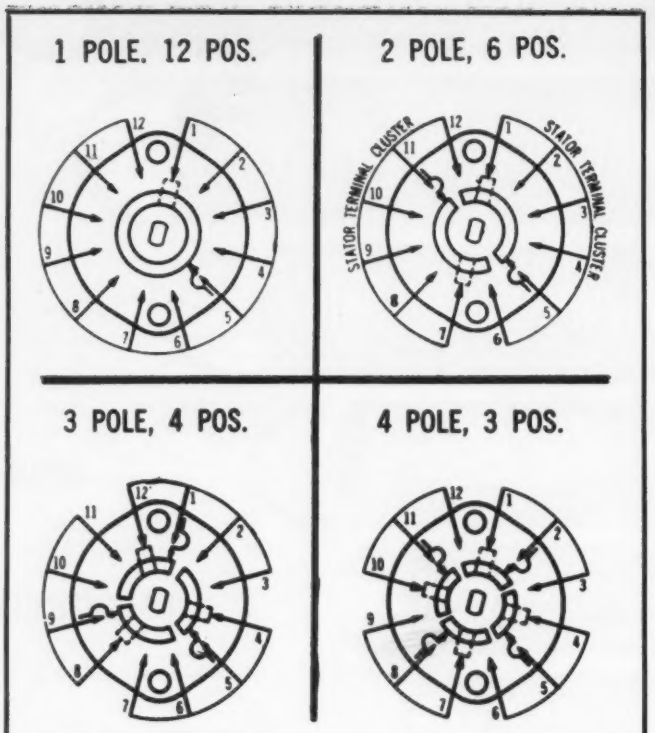

Fig. 11 Additional pole and contact configurations on rotary selector switch. This switch can provide one-pole contact with 12 distributing contacts on each deck. This permits switching with one pole, 12 distributing positions, 2 poles, 6 distributing positions, 3 poles, 4 distributing positions, or 4 poles with 3 distributing positions. This is accomplished by having each deck made of 3 wafers. The distributing contact opposite the pole contact is riveted through only one wafer allowing the middle wafer to act as the insulation between the pole contact and the distributing contact. Other contacts are riveted through the 3 wafers making the completed assembly a deck. At this time International Instruments, Inc. offers the switch with up to 6 decks.

and the switch positions for each pole. Fig. 10 shows a 4-pole, 3-position configuration. Fig. 11 shows additional contact arrangements in a diagram more closely approximating the actual physical appearance of these switches. Fig. 12 shows the appearance of a 6-deck rotary selector switch. Shorting (make-before-break) and non-shorting (break - before - make) contacts are available.

These switches can be broken down into two assemblies: a "detent assembly" and a "contact deck assembly". Detent assembly gives positive switch action and prevents shift in setting due to vibration.

In the rotary switch, the detent assembly is made up of a bushing and plate unit, and a shaft and index unit. Two steel balls carried in the bushing plate, and mounted on each side of the shaft, give the detent its indexing action. Springs apply pressure on these balls and create balanced shaft thrust preventing binding or seizing of the shaft in the bushing. Varying the spring pressure, produces varying torque (Fig. 13).

The detent is designed to give a feel and action like a toggle switch. In a toggle switch, operating force is stored in a spring. Switching takes place with a snap at maximum force and velocity. Arcing time between contacts is thus minimized, giving longer life to the contacts.

In the detent, the action is somewhat similar. Operating force is stored in the muscular tension of the hand. The detent lets go under maximum force and at maximum velocity so that by the time the contact tab has reached the mid-point of travel, the velocity has reached its maximum and the torque has decreased close to zero.

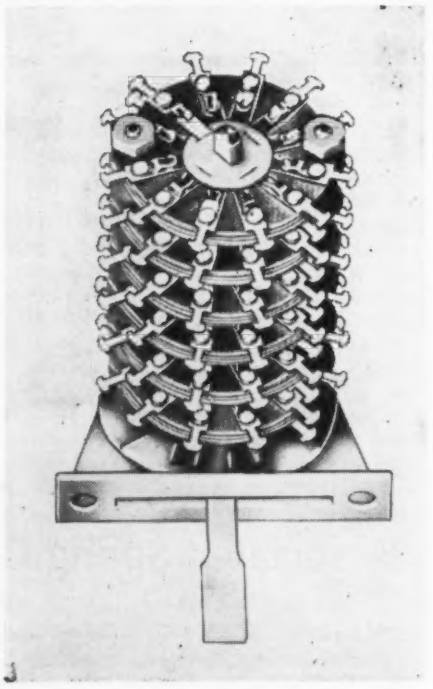

Fig. 12 Six-deck rotary selector switch by International Instruments, Inc.

This sudden drop of torque resistance in the detent allows the force in the hand to give the switch a high velocity.

The contact deck assembly consists of a wafer of high dielectric strength material possessing good arc-resistant as well as good general mechanical properties. Requirements are largely based upon the need for resistance to severe environments as discussed in Table II—immunity to moisture and extreme temperatures, high insulation resistance, particularly in miniature units with close contact separations, and the mechanical properties to permit use of the insulator as a contact support and major structural member. Particularly important is the ability to withstand shock and vibration without cracking.

Contacts are usually of the sliding type, providing the self-cleaning necessary for low contact resistances. Since most switches of the rotary selector type are used in low current electronic circuitry, silver or noble-metal alloys are generally recommended as contact materials. Contact resistance is of the order of a few milliohms.

Rotary-selector switches for military use are governed by MIL-S-3786, although, as with most electromechanical components, manufacturers are coming out with smaller and better units in response to immediate customer needs. In particular, miniaturization is being pushed by manufacturers of semi-conductor devices. Part II will summarize the requirements of MIL-S-3786; Table VI shows test results by one manufacturer on a miniaturized rotary selector switch in comparison with MIL-S-3786 requirements. While life depends a great deal on environmental conditions and contact loading, Tech Laboratories, Inc. indicates a life of over 1,000,000 cycles on a rotary selector switch for computer application.

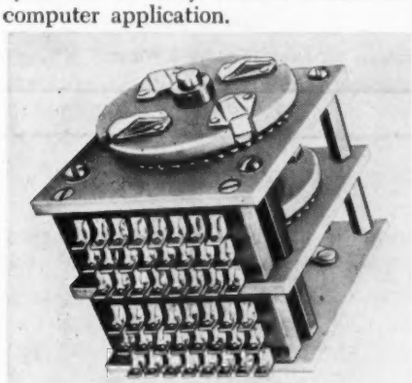

Fig. 16 Switch by Daven with side terminal board. This is an eight-pole switch (five positions per hole) with shorting-type action. Wiring is accomplished before the switch is fully assembled, making for improved reliability as compared with wiring in a relatively inaccessible position in a missile or airplane.

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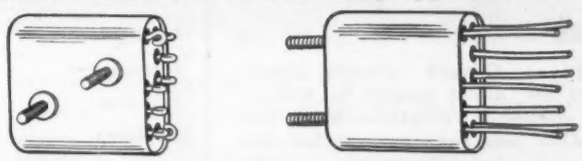

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All metal parts are fabricated from corrosion-resistant materials. Phenolics are heavily filled with non-organic fibres capable of withstanding high temperatures. Switch contacts are silver alloy. Wipers are rhodium-plated beryllium copper. Sixteen shorting and seven non-shorting switching arrangements are presently available in the Series G

PHOTO COURTESY CENTRALAB.

Fig. 14(a) Ganged printed circuit switches for direct plug-in to printed circuit connector receptacle. Since this illustration was taken, Centralab has modified the design by removing costly hardware from the insertion tab or terminal (bottom of switch). New design now incorporates the insertion tab as an extension of the phenolic wafer, as illustrated in Fig. 14(b).

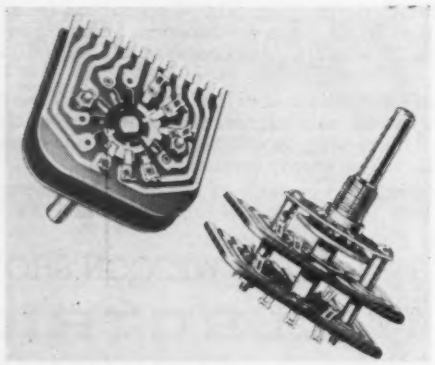

Fig. 14(b) Printed circuit rotary selector switch for plug-in application.

TABLE VI

TEST RESULTS VS. MIL-S-3786 REQUIREMENTS

TEST PERFORMED	TEST RESULTS	MIL-S-3786
Contact Resistance	.003-.004 ohms	.015 ohms
Dielectric Strength	Conforms to MIL Spec.	Paragraph 4.5.4.1
Torque	1½ inch lbs.	As specified
Terminal Strength	Conforms to MIL Spec.	Paragraph 4.5.6
Temperature Cycling	Conforms to MIL Spec.	Paragraph 4.5.7
Insulation Resistance	Over 50 megohms	10 megohms
Vibration	Conforms to MIL Specs.	Paragraph 4.5.9
Mechanical Shock	Conforms to MIL Specs.	Paragraph 4.5.10
Corrosion	Conforms to MIL Specs.	50 hour Salt Spray
Endurance	Over 10,000 cycles	10,000 cycles
Moisture Insulation (Wet) Resistance	Over 20 megohms	3½ megohms
Moisture Insulation Resistance (After Drying)	Over 50 megohms	10 megohms

TABLE VII

VARIOUS TYPES OF SWITCHES USED ON MOTOR VEHICLES

Antenna	Hydraulic	Push-pull
Aux. light	Ignition	Radio speaker
Back-up	Ingnition Interrupter	Release
Compartment Light	Key	Resistor Assembly
Defroster	Knobs	Rheostat
Diaphragm	Lever-operated	Rotary
Dimmer	Map and inst.	Selector
Disconnect	Master Switches	Slide
Door	Momentary	Solenoid
Escutcheon pl.	Overdrive kickdown	Spot light
Fan	Panel light	Starter
Face Plate	Panels	Stop light
Fog Light	Pillar	Toggle
Foot-operated	Pressure	Top lift
Fuel Tank	Push	Transmission
Headlamp	Pull	Tumbler and Key
Heater	Pushbutton	Windshield Wiper

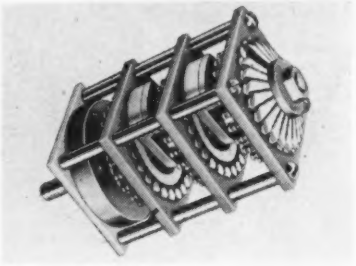

Fig. 15 Daven's new progressive shorting type switch shorts out every other position on the switch but the one actually in use. Particularly useful in the metering of a single position, the switch assures that ony one position is in operation at any one time. Switch's separate ring connection makes possible switching one meter between every position consecutively, continuous programming, and other special applications. Among other applications are capacitor decade switching, sequential power distribution, ammeter switching, voltmeter switching, control decks for rotary solenoid operation, and network sequencing applications. These switches can be ganged for multiple deck application. Solid silver alloy fingers, designed for self-wiping action ensure extremely low and uniform contact resistance. Contact materials and slip rings are made of solid silver alloy.

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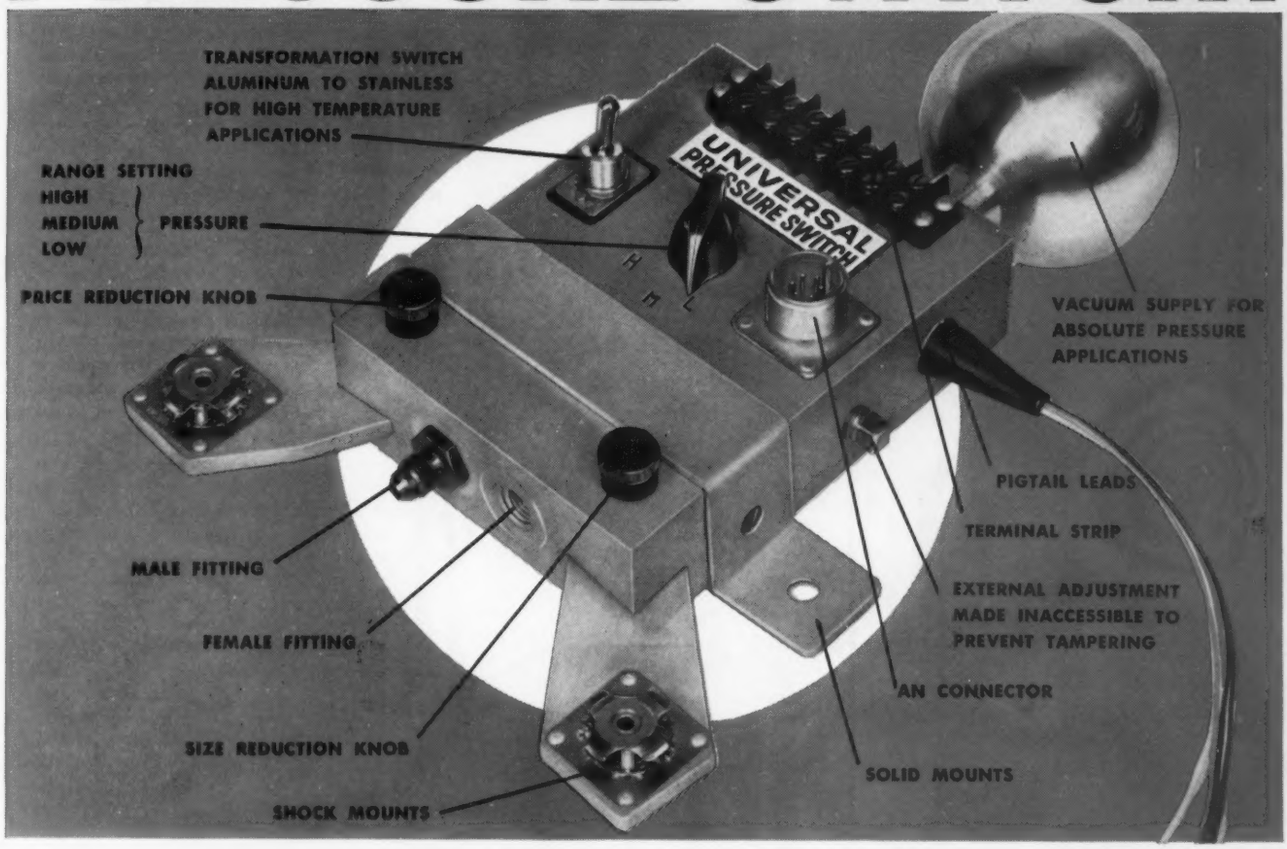

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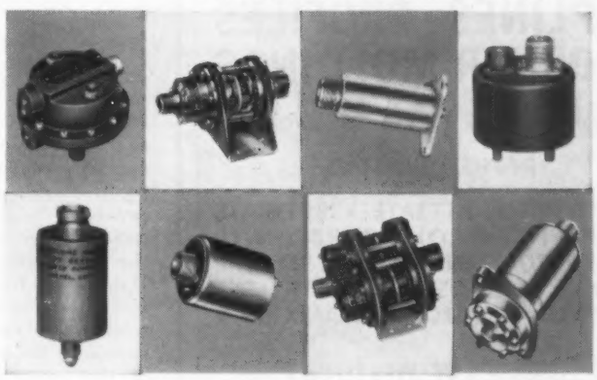

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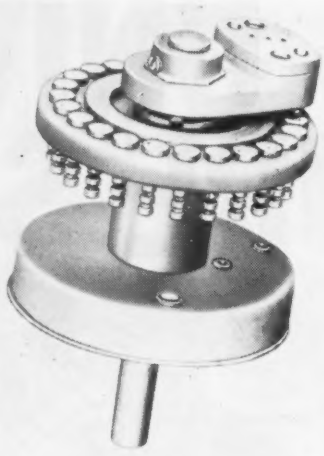


Fig. 19 Switches, using special gold-laminated contacts and slip rings for use in extremely corrosive atmospheres. In tests recently conducted on the Daven Type 11-CM-32 (a single-pole, 32-position, shorting type switch), the unit was suspended in a sulphur atmosphere at 45C for 245 hours. Initial contact resistance reading before suspension in this atmosphere was 0.001 ohm to 0.002 ohm. After completion of the tests, the contact resistance was still only 0.0021 to 0.0025 ohm. Gold-laminated contacts and slip rings are available where extreme reliability is demanded of a switch which will be used in a highly corrosive atmosphere.

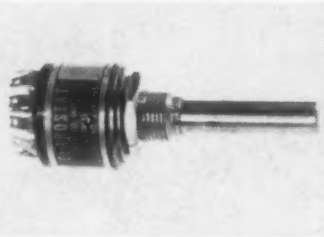


Fig. 20 Clarostat's miniature MIL-S-3786 rotary selector switch, with connections ranging from single-pole, 12-position to 4-pole, 3-position, shorting and non-shorting are available in the "Potpot" or encapsulated version for exceptionally high protection against moisture, temperatures and other environmental conditions.

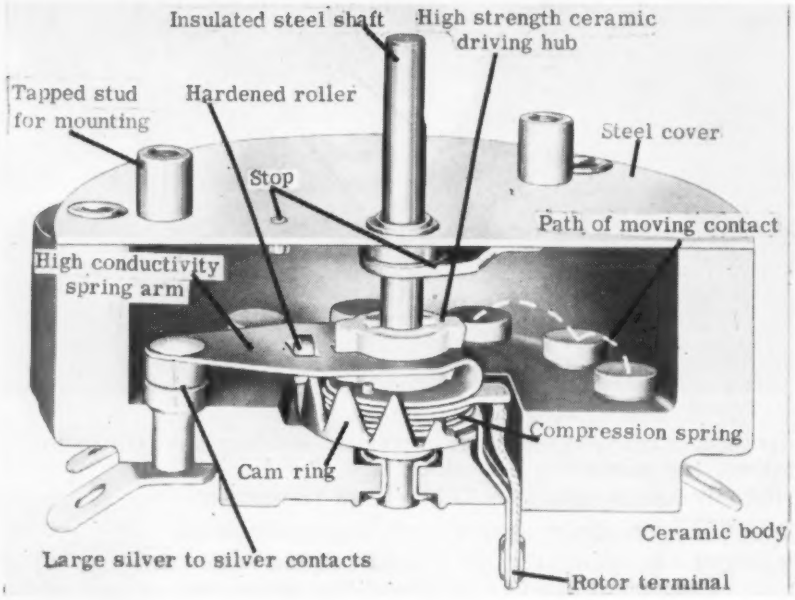


Fig. 21 "Slow-Break" mechanism specially designed for a-c use. A positive cam-and-roller mechanism provides "slow-break", quick-make action—the action proved best for the application of these switches. Operating time is only a small fraction of a second, but is "slow" relative to conventional fast-acting switches. Relatively slow separation of the contacts permits the circuit to open at about the instant when the alternating current wave reaches the zero point, hence minimizing sparking and greatly increasing the life of the contacts over that of conventional switches. Contact arm carries a hardened steel roller which follows the contour of a fixed cam ring as the arm is moved by the rotation of the shaft. This action lifts the spring arm (contact arm) so that the moving contact lifts from the fixed contact as it is rotated, in either direction, and descends under strong spring pressure with a slight wiping, self-cleaning action. Cam-ring and roller also index the moving contact on the fixed contact at each tap position. Recommended uses for tap switches such as these include: switchboards, rectifiers, heaters, motor control, ovens, tapped transformers, furnaces, x-ray equipment, dryers, diathermy equipment, arc welders, radio transmitters, spot welders, ventilating fan control, battery chargers, voltage regulators, electrical machine tools and test equipment.

(typical is a switch with one pole and up to ten positions shorting).

The switch is provided with an "O" ring panel seal and two "O" ring shaft seals. Space between "O" rings on the shaft is filled with silicone grease. Detenting is accomplished by means of a true detent mechanism. Switch extends an over-the-contact-distance of 9/16" behind panel.

Its ratings are: (a) 100,000 cycle life; (b) 125C temperature; (c) contacts 1 amp 250 volt d-c resistive and

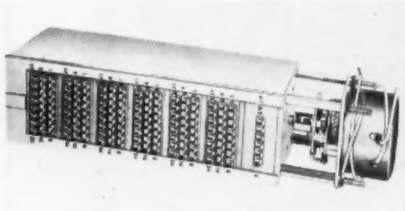


PHOTO COURTESY DAVEN

Fig. 17 Solenoid-operated, uni-directional rotary switch. Consisting of six poles with 24 non-shorting positions per pole, the new unit can be operated at temperatures up to 125C and at altitudes up to 80,000 feet. It withstands an acceleration of 50 G. Switch measures 2¾" square by 9" in overall depth, including the solenoid. In this unit, connections can be made from the switch body to a phenolic terminal board mounted on the side of the switch. In the field, connections can be made directly to the terminal board rather than to the switch itself. This facilitates the addition or subtraction of wires according to varying circuit requirements. Unit is completely enclosed in a dust cover and can be operated for over one million cycles.

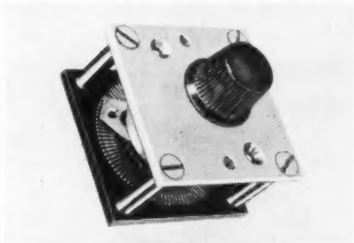
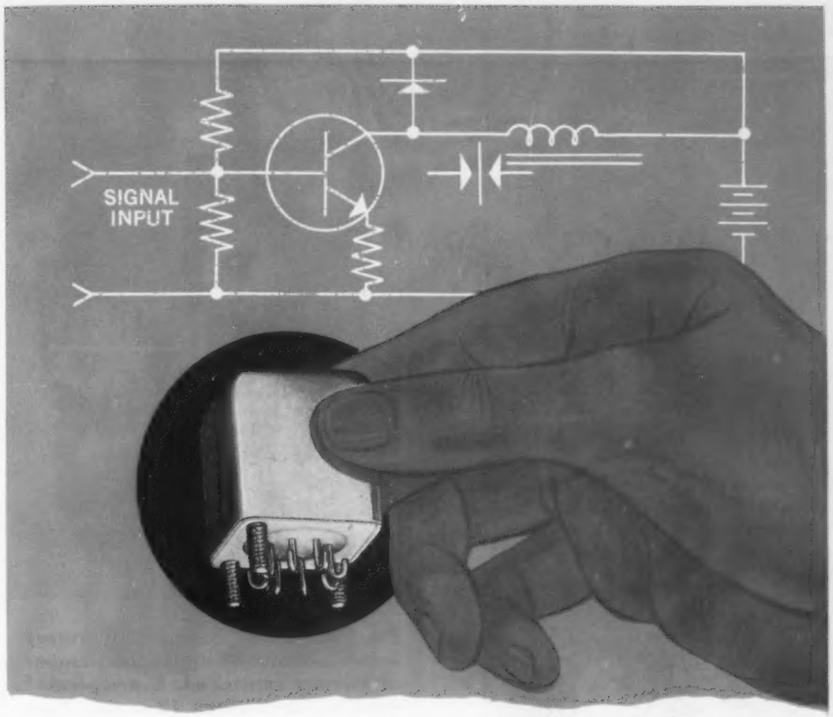


PHOTO COURTESY DAVEN

Fig. 18 New commutator type switch, for use in Detalink receivers, telemetering systems, high-speed commutators, and applications where 100 shorting positions or 50 non-shorting positions are required in an extremely small physical space. The single-pole switch has 100 positions in a panel space of only 1¾" square. Depth is ⅞". Space saving feature of this switch, which was developed specifically for use in missiles, is due to the molded wedge-shaped contacts set into the epoxy with extremely close contact spacing tolerances. Commutator bars are solid silver alloy and the rotor is beryllium copper with a welded silver edge making contact with the stator. Ratio of on-time to off-time on the unit shown in the figure is 1:1, but can be varied somewhat for special applications.



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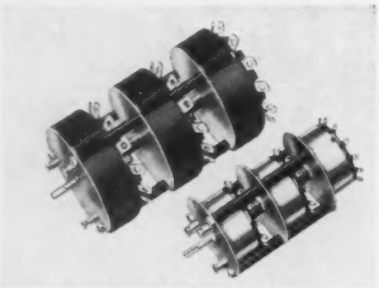

Fig. 22 Tandem assemblies are used to form multi-pole arrangements. Such switches are provided with extended shafts and are coup'ed together for single knob control, as shown.

PHOTO COURTESY OHMITE

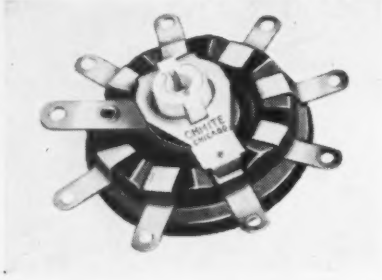

Fig. 23 Ridges, smoothly glazed with vitreous enamel, are located between the taps. Spacing between the taps decreases as the number of contacts increases (for a given total rotation). Circuit is opened as the contact leaves the tap. Indexing, and a modified snap action, is provided as the contact glides down over the ridge and onto the tap.

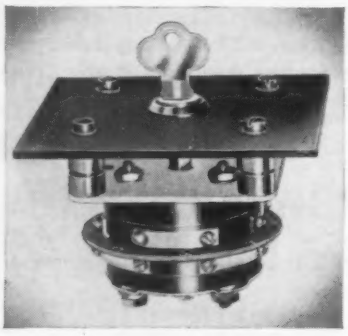

Fig. 24 Key-operated rotary switch by Electro Switch Corp. provides tamper-proof control of complex circuits. The key serves as the knob, and when removed, locks the switch in the se'ected position. This feature permits only authorized persons to change the position of the setting, and provides tamper-proof protection of complex electrical circuits. Key-operated Type JR ESCO switch provides control of up to three sections, eight positions, and the switch can be locked in any of the eight positions by key removal.

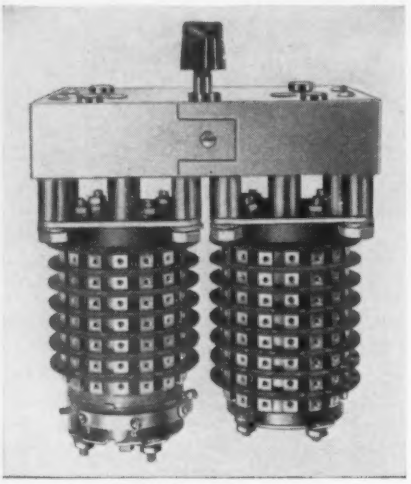

Fig. 25 New geared-pair rotary switch assembly doubles the number of circuits control'ed. Gear-operated pairs of 16-position, 12-section Esco rotary multipo'e switches double the number of electrical circuits that can be controlled by a single knob. This type of assembly keeps switch length to a minimum and, along with sturdy detent mechanism, assures positive positioning of rotors at each 22½ degree angle of rotation of the switch handle. Electrical rating (interrupting) is 5 amperes 125 volts a-c at 0.80 power factor. Contacts are non-shorting (break-before-make). The geared-pair assembly has 16 handle positions, 15 ON and 1 OFF position.

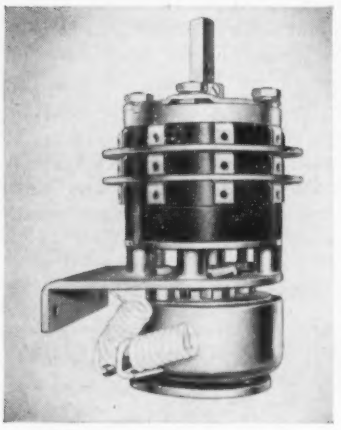

Fig. 26 Solenoid-operated, heavy duty rotary switches provide automatic, remote control of electrical circuits. Esco heavy-duty rotary multipole switches, assembled with so'enoid rotating devices that drive the switch through the cycle of contact positions, provide remote automatic or semi-automatic control of a series of complex circuits. The indexing stroke of the solenoid device is matched to the degree of rotation between contact positions of the switch, and drives the rotor one position each time the solenoid circuit is closed. The circuit may be closed by push-button or by simple mechanical motion of the governed machine, providing the control needed for automation.

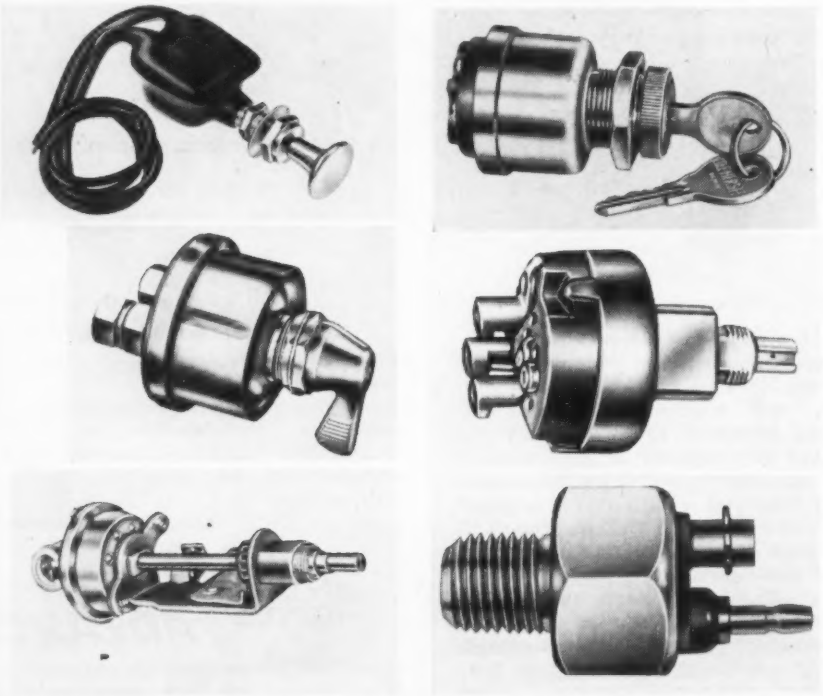

Fig. 27 Special purpose switches by Cole-Hersee for the automobile industry. A great many types are used on motor vehicles, as listed in Table VIII. Switches such as these illustrate the tremendous variety found throughout industry.

Fig. 28 Subminiature, snap-acting switch is used where cam applies operating force, as in many types of automatic equipment.

Fig. 29 Unimax Subminiature snap-acting switch is designed for use where ambient temperatures are high and available space is low.

350 ma 100 volt d-c inductive; (d) contact resistance less than 0.008 ohms; (e) dielectric strength 1000 volts RMS between terminals or to ground; (f) low capacity between all parts.

Printed Circuit Switches

Printed circuit switches fall into two categories: those employing printed-circuitry as a method of economical switch manufacture, and those designed for use in conjunction with printed devices. Fig. 14 illustrates both these types. Of particular interest is the printed circuit switch for insertion in printed circuit boards, eliminating the necessity of hand wiring each switch terminal, as well as eliminating the possibility of wiring errors.

Because of the relatively complex contact arrangements possible in rotary selector switches, manufacturers have prepared standard formats and guides to assist in preparing an accurate specification. Table VII shows portions of a particularly complete guide prepared by Centralab, which is included here for its values as a check list of specification factors for this type.

SWITCH VARIATIONS

Because a suitable switch design can often simplify the function of an otherwise difficult to use piece of equipment, many special-purpose rotary selector switches have been developed, typical types being shown in the following figures. Captions amply describe these types.

Part II of the Components Digest on switches will appear in our October issue. This part covers additional switch varieties, such as: push-button, mercury tilt, crossbar, stepping, thermal sensing, pressure sensing, limit and proximity as well as highly specialized types.

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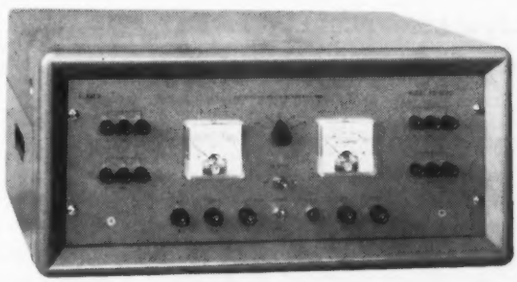

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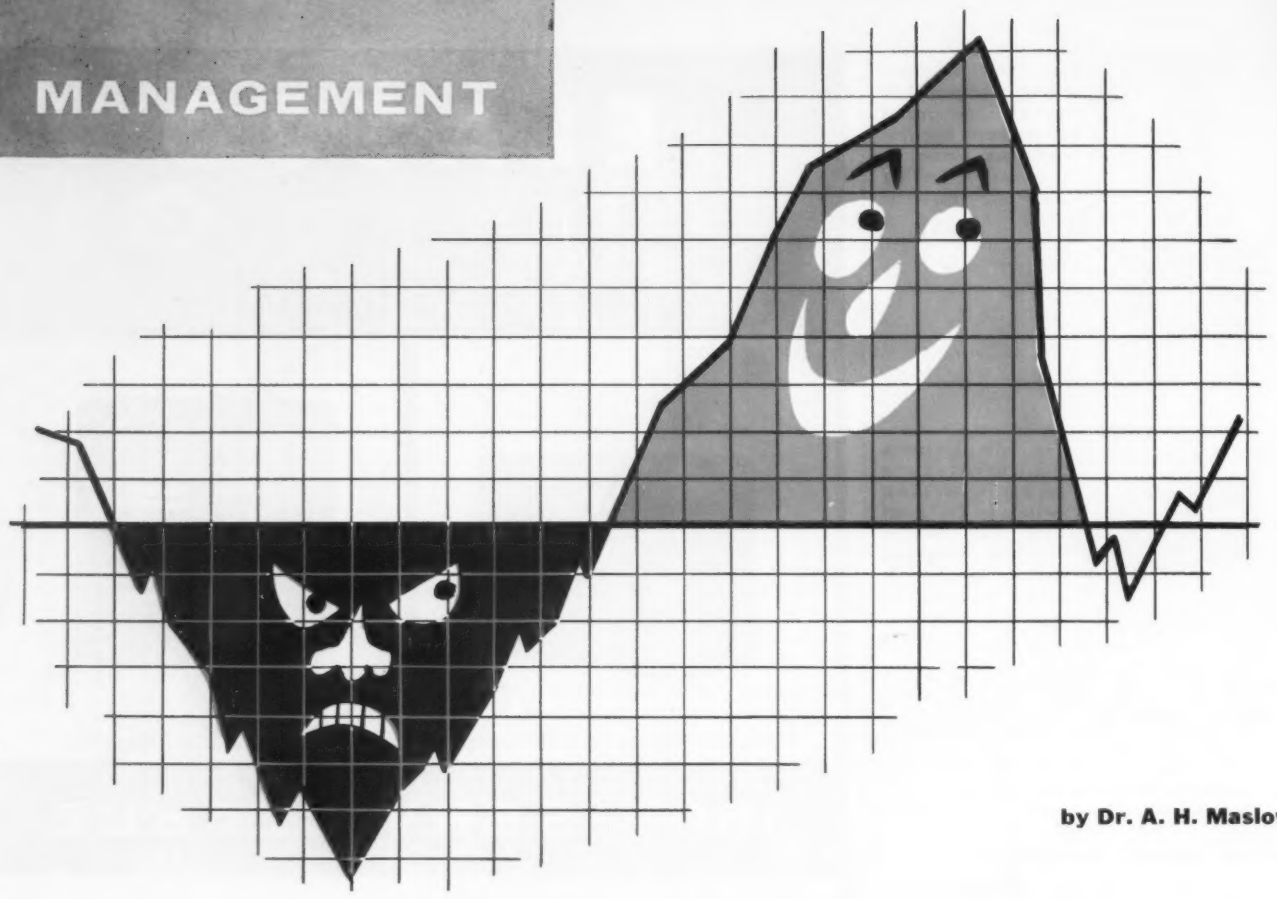

by Dr. A. H. Maslow

CREATIVITY IN SELF-ACTUALIZING PEOPLE—Part 2

The "Peak"

Part I appeared in our Jan. 1959 issue; a limited amount of reprints are available at 50 cents each. Check, money order or coin must accompany each order.

Another later investigation on "peak-experiences" supported and enriched these conclusions. What I did was to question many persons (not only healthy ones) about the most wonderful, most ecstatic experiences of their lives. This started out as an attempt to make a generalized, all-inclusive theory of the changes of cognition which had been described in the various specific literatures on the creative experience, the esthetic experience, the love experience, the insight experience, the orgasmic experience, and the mystic experience. The generalized word I used for all these happenings was "peak-experience." It was my impression that each of these experiences changed the person and his perception of the world in similar or parallel ways. And I was impressed by the fact that these changes often seemed to parallel my already-described self-actualization, or at least effect a transient unifying of the splits within the person.

So it turned out. But here, too, I learned that some comfortable beliefs I had held had to be given up. For one thing, I had to respect constitutional differences of the Sheldonian sort more than I had. Charles Morris reports a similar experience in **Varieties of Human Value** (Univ. Chicago Press, 1956). Different kinds of people get their peak-experiences from different kinds of happenings. But no matter where they get them from, the subjective experience is described in about the same way. And I assure you that it was a very startling thing for me to hear a woman describing her feelings as she gave birth in the same words used by Buck to describe "cosmic consciousness" or by Huxley to describe the "mystic experience" in all cultures and eras or by Ghiselin to describe the creative process or by Suzuki to describe the Zen "satori" experience. It opened up for me also the possibility of different kinds of creativeness, as well as of health, etc.

However, the main finding relevant to our present topic was that an essential aspect of the peak-experience is integration within the person and therefore between the person and the world. In these states of being, the person becomes unified; for the time being, the splits, polarities and dissociations within him tend to be resolved; the civil war within is neither won nor lost but transcended. In such a state, the person becomes far more open to experience and far more spontaneous and fully functioning—essential characteristics, as we have already seen, of creativeness. I quote from my forth-coming article "Cognition of Being in the Peak-Experiences"in **J. Genet. Psychol ('59):**

"One aspect of the peak-experience is a complete, though momentary, loss of fear, anxiety, inhibition, defense and control, a giving up of renunciation, delay and restraint. The fear of disintegration and dissolution, the fear of being overwhelmed by the 'instincts', the fear of death and of insanity, the fear of giving in to unbridled pleasure and emotion, all tend to disappear or go into abeyance for the time being. This, too, implies a greater openness of perception since fear distorts.

It may be thought of as pure gratification, pure expression, pure elation. But since it is 'in the world,' it represents a kind of fusion of the Freudian 'pleasure principle' and 'reality principle'."

Observe that these fears are all of our own depths. It is as if in the peak-experience we accepted and embraced our deeper selves instead of controlling and fearing them.

"For one thing, not only the world but also he himself becomes more a unity, more integrated, and self-consistent. This is another way of saying that he becomes more completely himself, idiosyncratic, unique. And since he is so, he can be more easily expressive and spontaneous without effort. All his powers then come together in their most efficient integration and coordination, organized and coordinated much more perfectly than usual. Everything then can be done with unusual ease and lack of effort. Inhibition, doubt, control, self-criticism, diminish toward a zero point and he becomes the spontaneous, coordinated, efficient organism, functioning like an animal without conflict or split, without hesitation or doubt, in a great flow of power that is so peculiarly effortless, that it may become like play, masterful, virtuoso-like. In such a moment, his powers are at their height and he may be startled (afterwards) by his unsuspected skill, confidence, creativeness, perceptiveness and virtuosity of performance. It is all so easy that it can be enjoyed and laughed with. Things can be dared that would be impossible at other times.

"To put it simply, he becomes more whole and unified, more unique and idiosyncratic, more alive and spontaneous, more perfectly expressive and uninhibited, more effortless and powerful, more daring and courageous (leaving fears and doubts behind), more ego-transcending and self-forgetful."

And since almost everyone I questioned could remember such experiences, I had to come to the tentative conclusion that many, perhaps most, people are capable of temporary states of integration, even of self-actualization and

Experience

therefore of SA creativeness (of course, I must be very tentative in view of my very casual and inadequate sampling).

PRIMARY, SECONDARY, AND INTEGRATED CREATIVENESS

Classical Freudian theory is of little use for our purposes and as a matter of fact is partially contradicted by our data. It is (or was) essentially an id-psychology, an investigation of the instinctive impulses and ther vicissitudes, and the basic Freudian dialectic is seen to be ultimately between impulses and defenses against them. But far more crucial than repressed impulses for understanding the sources of creativity (as well as the sources of play, love, enthusiasm, humor, imagination, and fantasy) are the so-called primary processes which are essentially cognitive rather than conative. As soon as we turn our attention to this aspect of human-depth-psychology, we find much agreement betwen the psychoanalytic ego-psychology (Kris, Milner Ehrenzweig), the Jungian psychology, and the American self-and-growth psychology.

The normal adjustment of the average, common sense, well adjusted man implies a continued successful rejection of much of the depths of human nature, both conative and cognitive. To adjust well to the world of reality means a splitting of the person. It means that the person turns his back on much in himself because it is dangerous. But it is now clear that by so doing, he loses a great deal too, for these depths are also the source of all his joys—his ability to play, to love, to laugh, and, most important for us, to be creative. By protecting himself against the hell within himself, he also cuts himself off from the heaven within. In the extreme instance, we have the obsessional person, flat, tight, rigid, frozen, controlled, cautious, who can't laugh or play or love or be silly or trusting or childish. His imagination, his intuitions, his softness, his emotionality tend to be strangulated or distorted.

The goals of psychoanalysis as a therapy are ultimately integrative. The effort is to heal this basic split by insight, so that what has been repressed becomes conscious or preconscious. But here again we can make modifications as a consequence of studying the depth sources of creativeness. Our relation to our primary processes is not in all respects the same as our relation to unacceptable wishes. The most important difference that I can see is that our primary processes are not as dangerous as the forbidden impulses. To a large extent they are not repressed or censored but rather are forgotten, as Schachtel has shown in his article "On Memory and Childhood Amnesia" for **Psychiatry** (1947, 10, 1-26), or else turned away from, suppressed, (rather than repressed) as we have to adjust to a harsh reality which demands a purposeful and pragmatic striving rather than reverie, poetry, play. Or to say it in another way, in a rich society, there must be far less resistance to primary thought processes. I expect that education processes, which are known to do rather little for relieving repression of "instinct," can do very much to accept and integrate the primary processes into conscious and preconscious life. Education in art, poetry, dancing, can in principle do much in this direction. And so also can education in dynamic psychology; for instance, Deutsch and Murphy's **Clinical Interview,** which speaks in primary process language, can be seen as a kind of poetry. Marion Milner's extraordinary book **On Not Being Able To Paint** perfectly makes my point.

The kind of creativeness I have been trying to sketch out is best exemplified by the improvisation, as in jazz or in child-like paintings rather than by the work of art designated as "great." In the first place, the great work needs great talent which, as I found, turned out to be irrelevant for my concern. In the second place, the great work needs not only the flash, the inspiration, the peak-experience, it also needs hard work, long training, unrelenting criticism, perfectionistic standards. In other words, succeeding upon the spontaneous is the deliberate; succeeding upon total acceptance comes criticism; succeeding upon intuition comes rigorous thought; succeeding upon daring comes caution; succeeding upon fantasy and imagination comes reality testing. Now come the questions, "Is it true?" "Will it be understood by others?" "Is its structure sound?" "Does it stand the test of logic?" "How will it do in the world?" "Can I prove it?"

Now come the comparisons, the judgments, the evaluations, the cold, calculating, morning-after thoughts, the selections and the rejections.

If I may say it so, the secondary processes now take over from the primary, the Appolonian from the Dionysian, the "masculine" from the "feminine". The voluntary regression into our depth is now terminated, the necessary passivity and receptivity of inspiration or of peak-experience must now give way to activity, control, and hard work. A peak-experience happens *to* a person; but the person *makes* the great product. It could be described as

WORTH BUYING

CREATIVITY

Three articles on creativity were published in July in ETC.: A Review of General Semantics, Volume XVI, No. 3, 1959. The Nature of Creativity by Rollo May, Creativity as Personality Development by Harold H. Anderson, and Creative Resources: Their Care and Nurture by Franklin J. Shaw. Single copies of this issue may be obtained for $1.00 from the Editor, Professor S. I. Hayakawa, San Francisco State College, San Francisco 27, California.

a masculine phase succeeding upon a feminine one.

Strictly speaking, I have investigated this first phase only, that which comes easily and without effort as a spontaneous expression of an integrated person or of a transient unifying within the person. It can come only if a person's depths are available to him, only if he is not afraid of his primary thought processes.

I shall call "primary creativity" that which proceeds from and uses the primary process much more than the secondary processes. The creativity which is based mostly on the secondary thought processes, I shall call "secondary" creativity. This latter type includes a large proportion of production-in-the-world, the bridges, the houses, the new automobiles, even many scientific experiments and much literary work which are essentially the consolidation and exploitation of other people's ideas. It parallels the difference between the commando and the military police behind the lines, the pioneer and the settler. That creativity which uses *both* types of process easily and well in good fusion or in good succession, I shall call "integrated creativity." It is from this kind that comes the great work of art or philosophy or science.

CONCLUSION

The upshot of all of these developments can, I think, be summarized as an increased stress on the role of integration (or self-consistency, unity, wholeness) in the theory of creativenes. Resolving a dichotomy into a higher, more inclusive unity amounts to healing a split in the person and making him more unified. Since the splits I have been talking about are within the person, they amount to a kind of civil war, a setting of one part of the person against another part. In any case, so far as creativeness SA is concerned, it seems to come more immediately from fusion of primary and secondary processes rather than from working through the repressive control of forbidden impulses and wishes. It is, of course, probable that defenses arising from fear of these forbidden impulses also push down primary processes a kind of total undiscriminating, panicky war on *all* the depths, But it seems that such lack of discrimination is not, in principle, necessary.

To summarize, creativeness SA stresses first the personality rather than its achievements, considering these achievements to be epiphenomena emitted by the personality and therefore secondary to it. It stresses characterological qualites like boldness, courage, freedom, spontaneity, perspicuity, integration, self-acceptance, which make possible the kind of generalized creativeness I've been talking about, which, in turn, expresses itself in the creative life or the creative attitude or the creative person. I have also stressed the expressive or "Being" quality of creativeness SA rather than its problem-solving or product-making quality. Creativeness SA is "emitted" like radioactivity and hits all of life, regardless of problems, just as a cheerful person "emits" cheerfulness without purpose or design or even consciousness. It is emitted like sunshine; it spreads all over the place; it makes some things grow (which are growable) and is wasted on rocks and other ungrowable things.

As I come to the end I am quite aware that I have been trying to break up widely accepted concepts of creativity without being able to offer in exchange a nice, clearly defined, clean-cut substitute concept. Creativeness SA is hard to define because sometimes it seems to be synonymous with health itself, as Moustakas has suggested in **The Self** (Harpers 1956). And since self-actualization or health must ultimately be defined as the coming to pass of the fullest humanness, or as the "Being" of the person, it is as if creativity SA were almost synonymous with, or a **sine qua non** aspect of, or a defining characteristic of, essential humanness. *END*

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Combined Plug-Socket

A new universal electric connector, a combined plug-or-socket unit handles up to 26 circuits and eliminates the need for matching male with female connectors in communications and other equipment. A $1,200,000 Defense Department contract for the device has been received, and production is under way, said Mr. H. R. Cammer, president of Specialty Electronics Development Corporation, pointing out that the connector, first of its kind to be made in the U. S., "has a number of valuable commercial applications in telephone, telegraph and other electrical circuits". The new type connector, a "non-reversing hermaphrodite", acts as both plug and socket at either end of a multi-circuit telephone or telegraph cable, and is highly important for military purposes in making rapid connections under mobile field conditions. Any connector can be plugged directly into another without regard to polarity or change in conductor path. The unit being made under the current defense contract, Mr. Cammer said, is designed to connect up to 26 circuits in a telephone cable. The basic principle, however, can be used for a single power or communications circuit, or an even larger number of cable circuits if required. "Eliminating the need for adapters or junction boxes in any type of electrical hook-up, either for power communications, the new connector eliminates the potential error of mismatching cable ends, or the possible need for soldering new connections. It also provides substantial operating economics since there is no need to carry inventories of adapters and junction boxes." Specially designed for the rugged field conditions, the unit is only 2½ inches in diameter and 7 inches long. Of completely waterproof construction, it has a unique arrangement of pins for maximum insulation of each circuit. All electrical contacts are gold-plated to prevent corrosion and loss of conductivity.

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CIRCLE 41 ON INQUIRY CARD →

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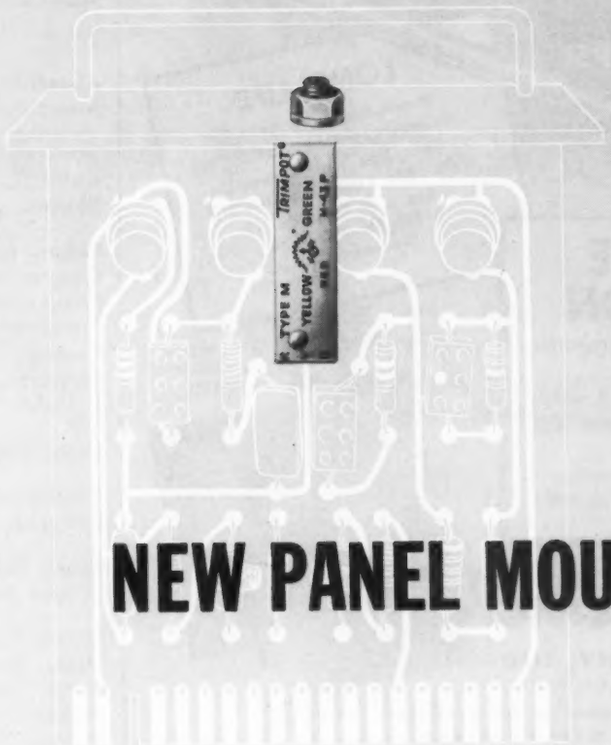
BOOTHS 2810 – 2812

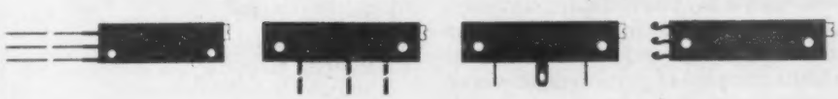


NEW PANEL MOUNT TRIMPOT®

Now, Bourns combines the convenience of a panel mount potentiometer with all the advantages of a rectangular unit—**Small Size:** requires 1/12 sq. in. or less of panel area—**Setting Stability:** self-locking shaft with no cumbersome locknuts—**Adjustment Accuracy:** multiturn shaft provides up to 9000° rotation.

All of the many Trimpot models are now available with the panel mount feature as a result of a unique design that permits quick attachment of a panel mounting assembly to standard "on-the-shelf" potentiometers. Rugged stainless steel construction assures compliance to Mil-Specs for vibration, shock, salt spray, etc. Screwdriver adjustment is easily made from the front of the panel...recessed head prevents accidental changes of setting...silicon rubber O-ring and Teflon washer provide moisture barrier from outside elements.

Specify the panel mount Trimpot. Get reliability backed by years of engineering, manufacturing and field experience. **Write for complete data and list of stocking distributors.**



CHASSIS MOUNTING, PRINTED CIRCUIT OR PANEL MOUNTING—whatever your need, Bourns has a military or commercial potentiometer to meet your exact requirements. Choice of terminal types...resistances from 10 ohms to 1 Meg.

BOURNS, Inc.

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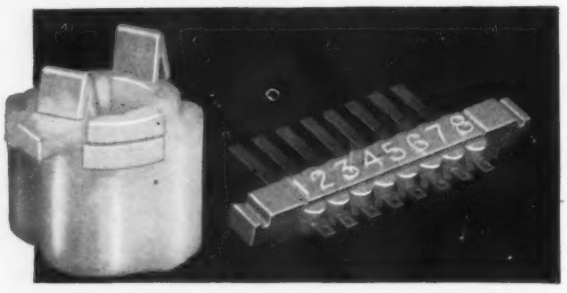

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CIRCLE NO. 31 ON INQUIRY CARD

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NEW . . .

UNIMAX CATALOGS

Catalog No. 159
Covers subminiature high-temperature (up to 650°F), commercial, MIL-type, environment-free, and toggle switches — 16 pages.

Catalog No. 359
Describes sealed, low-cost, general-purpose, low-force, high-sensitivity, environment-free, metal-cased, AN and JAN, direct-current, and reset precision snap-acting switches — 28 pages.

Complete engineering data: dimension drawings, force and movement specifications, electrical ratings, integral and auxiliary actuators, bases, terminals, circuit arrangements, and NEMA standard definitions of sensitive-switch terms.

Write today for your copy.

UNIMAX SWITCH
Division The W. L. Maxson Corporation
IVES ROAD, WALLINGFORD, CONNECTICUT

CIRCLE 50 ON INQUIRY CARD

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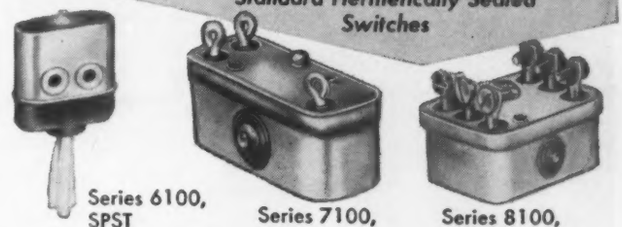
HAYDON . . . RELIABLE SOURCE FOR MINIATURE SNAP-ACTION SWITCHES

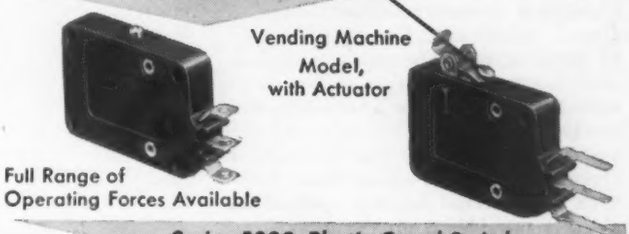
Standard Hermetically Sealed Switches



Series 6100, SPST — Series 7100, SPST — Series 8100, DPDT

These switches meet requirements of MIL-S-6743 and MIL-E- 5272A, Procedure II (vibration).

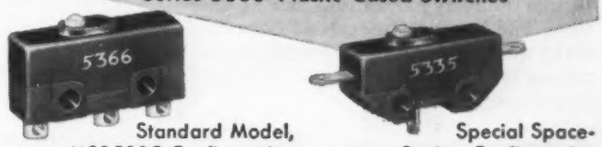
Series 5200 Plastic Cased Switches



Full Range of Operating Forces Available

Vending Machine Model, with Actuator

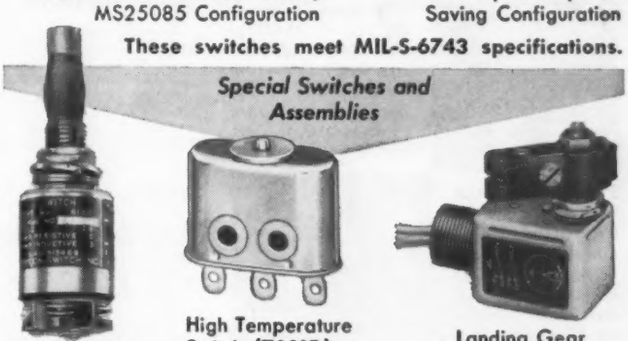
Series 5300 Plastic Cased Switches



Standard Model, MS25085 Configuration — Special Space-Saving Configuration

These switches meet MIL-S-6743 specifications.

Special Switches and Assemblies



Aircraft Limit Switch — High Temperature Switch (700°F.) — Landing Gear Switch

These are only a few of the many precision switches developed by Haydon for aircraft and industrial applications. Haydon engineers are prepared to solve *your* switch design problems—or call on one of their twenty-three field offices for immediate help.

For accurate, dependable performance in miniature and subminiature switches, it pays to contact Haydon Switch!

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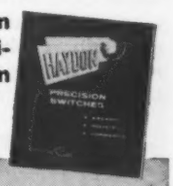

HAYDON *Switch* INCORPORATED
WATERBURY 20, CONNECTICUT

CIRCLE 51 ON INQUIRY CARD

LOCTITE secures 98 studs against vibration

Locking studs with Loctite Liquid Sealant in transmission unit of jet aircraft starter.

Cast aluminum gear cases for jet aircraft starters are machined and assembled at The Black Rock Manufacturing Company, successor to Reed-Prentice Corp., Bridgeport, Connecticut. The 98 studs used in the unit are treated with LOCTITE Sealant to secure them against vibration. The jet starter units receive an input of 2500 rpm and develop output of 5000 rpm to each of three flexible shaft connections. LOCTITE was selected for this application since it provides a greater prevailing torque than any mechanical locking device. The locking strength of LOCTITE is not affected by the wide temperature ranges the unit encounters in arctic to tropic operation.

Stud thread is hand-dipped in shallow tray of Loctite, then positioned in casting for tightening. Three sizes of steel studs are used: ¼"-20, ⅛"- 18 and ⅜"-16.

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LOCTITE Sealant is a thin liquid that hardens into a tough heat and oil-resistant plastic bond when confined between closely fitting metal parts. No amount of vibration will shake loose a LOCTITE treated threaded fastener, yet ordinary tools may be used to remove the part. LOCTITE is used to hold bearings, bushings, or hardened sleeves to shafts without press fit; seals joints against high pressure fluids. Write for literature and free sample.

LOCTITE® SEALANT

AMERICAN SEALANTS COMPANY

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Circle 46 on Inquiry Card

For Your 3-Ring Binder

NEW DATA SHEETS

For your free copy of the data sheets listed on this page, circle the appropriate number of the item on the Inquiry Card.

SIZE 11 POTENTIOMETER 183

Designed to meet the need for a precision miniature servo component relating shaft position to an a-c voltage, Series 4 Vernistat pots feature high linearity, low phase shift, high input and low output impedance. Specifications, design benefits and general application information. Vernistat Div., Perkin-Elmer, Norwalk, Conn.

PORTABLE BALANCER 164

Instrument is adjustable to any job from below 10 millionths of an inch to over 1/10" to 1/8" amplitude of vibration for eliminating vibration in grinding wheels and cutter heads, detecting vibration caused by worn bearings, belts and misalignment and for balancing all assembled equipment such as blowers, fans, pumps, turbines, rolls, motors, engines, drive shafts, generators, machine tool spindles, gears, couplings and chucks. Stewart Warner Corporation, Chicago, Illinois.

RADIATION RESISTANT SERVOMOTOR 177

Servomotor operates effectively at temperatures ranging from —54C to +200C withstands 10^8 through 10^{10} roentgens of radiation and has a high torque-to-inertia ratio. Kearfott Co., Clifton, N. J.

AIRBORNE PRESSURE SWITCHES 173

General-purpose pressure switches including pneumatic and hydraulic types, high vibration models and differential pressure units; special application units such as altitude switches, high-temperature 650F models and pressure ratio switches, and aircraft gauges. Consolidated Controls Corp., Bethel, Conn.

CASE LATCH 159

Locking devices for use on rigidly specified military cases and commercial containers lie flat against mounting surface extending just 7/16" from container surface. Simmons Fastener Corp., Albany, N. Y.

TRANSISTORIZED POWER INVERTER 260

Used to drive ac gyros and other ac devices from a battery source, this transistorized regulated power inverter incorporates a unique circuit which eliminates the tendency of ac gyro spin motors to hunt when near synchronous speed. The output waveshape of the inverter is sinusoidal—avoiding the heat-producing harmonic currents which are characteristic of square wave operation. Arnold Magnetics Corp., Los Angeles, California.

SELENIUM RECTIFIERS 253

Catalog contains complete descriptions, data and specifications for glass or phenolic tube cartridge selenium rectifiers. Syntron Co., Homer City, Penn.

TRANSISTOR POWER DISSIPATION 244

Methods of determining the maximum power dissipation in transistors, and the effects of maximum power dissipation on circuit considerations and factors to consider in arriving at an allowable collector dissipation such as thermal runaway are illustrated and discussed in pamphlet. Valor Instruments, Inc., Gardena, Calif.

SYNCHRO TRANSMITTERS 175

Transmitters specifically designed for the requirements of air and missile borne electronics, weigh less than half an ounce, with standard accuracy held to within 10 min. Daystrom Transicoil, Worcester, Pa.

SELF-SEALING COMPONENTS AND FASTENERS 174

Description of a complete line of single-unit, high-pressure seals and fasteners suitable for military, commercial and industrial applications. Includes toggle switch boots, rotary shaft seals, push button switch boots and indicator light seals, presented by means of engineering drawings and complete specifications in tabular form. A. P. M. Corporation, Yonkers, N. Y.

TRANSISTOR DATA 251

Transistor chart lists typical operation and maximum ratings of production transistors. Semiconductor Products, Bendix Aviation Corporation, Long Branch, New Jersey.

PRESSURE PICKUP 240

Small light-weight transducer, in absolute or gage models in pressure ranges from 100 to 5000 psi, is especially adaptable to pressure measuring in corrosive, explosive or radioactive atmospheres, such as those encountered in water depth-determination, pressures in oil wells, liquid oxygen systems and gas or pipe lines. Consolidated Electronics, Pasadena, California.

COUNT RATE METERS 252

7 models of series CRM count rate meters including linear, log, and differential count rate units. Bulletin suggests uses and applications, describes circuits, ranges, etc. Victoreen Instrument, Cleveland, Ohio.

SIGNALING CONTROLLER 245

Designed for two-position (OFF-ON) control, this potentiometer type instrument is used for accurate and automatic control of many industrial processes, furnaces, ovens, molding machines, casting machines, pickling tanks, and extruders and may be used with any sensing element that generates a DC signal. Corrective action occurs almost simultaneously with deviation of the input signal from the preset control point. Thermo Electric Co., New York, N.Y.

PRINTED CIRCUIT POT 172

Hermetically sealed, wire-wound, subminiature circuit balancing pots, less than 3/16 x 5/16 x 1, operate at 1.0 watt and a maximum temperature of 175C. Trimpot Div., Bourns Labs., Inc., Riverside, Cal.

VOLTAGE REGULATORS 155

60 page booklet gives application, description, selection, weights, dimensions, and connection diagram for G. E.'s redesign of dry type and liquid filled voltage regulators 60 and 400 cycles. Dry type single-phase units are offered in ratings up to 180 kva, 600 volts and below, three-phase up to 720 kva for industrial and electronic applications, with manual, motor-driven, or automatic control; liquid filled units are rated up to 2,200 kva, 13,800 volts and below. General Electric Co., Pittsfield, Mass.

AIRCRAFT TEMPERATURE CONTROL 158

An electromechanical system control amplifier, rotary actuator, thermistor probe automatically holds temperature of liquids, air or solids within prescribed limits in aircraft, missile and related applications. Airborne Accessories Corp., Hillside, N. J.

HIGH AND LOW PRESSURE IN-LINE FILTERS 153

High and low pressure T-type in-line filter assemblies, replacement filter elements, dual bowl filters and differential pressure indicator filter assemblies for filtering liquid oxygen (minus 300F); liquid nitrogen; aviation gasoline; kerosene, RP-1; JP-4; JP-5; Mil-H-5606; OS-45; Skydrol 500; Oronite 8200; Oronite 8515; Water: acetone; gaseous nitrogen; helium; Mil-L-7808; lubrication oils; and other related fluids range from 2 to 250-microns, and cover flow ranges from one to 24-gpm with Mil-H-5606 and 200 to 2,500-scfm with air at 3000 psi. Bendix Aviation, Madison Heights, Michigan.

3-RING SPEED REDUCERS 157

Four page brochure details self-cooling, fin and fan equipped speed reducers. Ohio Gear Co., Cleveland, Ohio.

REED RELAY 156

Incorporating the double reed principle, these relays have applications in selective signalling systems, control systems, vibration analysis and telemetering. One particular provides 32 channels from 300 to 1000 cps., band widths of less than 1½ per cent with a sensitivity of 1.5 milliwatts is less than ½ inch square by 1⅛ inch in length, weighing less than 10 grams. North Tonawanda Division, The Wurlitzer Company, North Tonawanda, N. Y.

TEMPERATURE INDICATION AND CONTROL 169

Series of data sheets on direct reading temperature indicators, thermal ribbons for measurement and control, resistance temperature detector and thermal heaters contain engineering application specs for design engineers. Minco Products, Inc., Minneapolis, Minn.

PULSE GENERATOR 257

Pulse generator for calibration of multichannel pulse height analyzers with 2^n channels. The Victoreen Instrument Co., Cleveland, Ohio.

PRINTED CIRCUIT CONNECTORS 150

Catalog contains electrical and mechanical specifications, dimensional drawings and basic design features on a new series of two-unit connectors for use in printed circuitry. Uses include: connector networks for guided missiles, radar computers, communication systems and forms of instrumentation for ground and airborne application, both military and commercial. U. S. Components, Inc., New York, N. Y.

THERMISTOR TEMPERATURE CONTROL 181

Complete specifications, available temperture sensing probes, and suggested applications of new transistorized thermistor controller, Series 535, for packaging, printing, synthetic fiber processing and general industrial storage. Fenwal, Inc., Ashland, Mass.

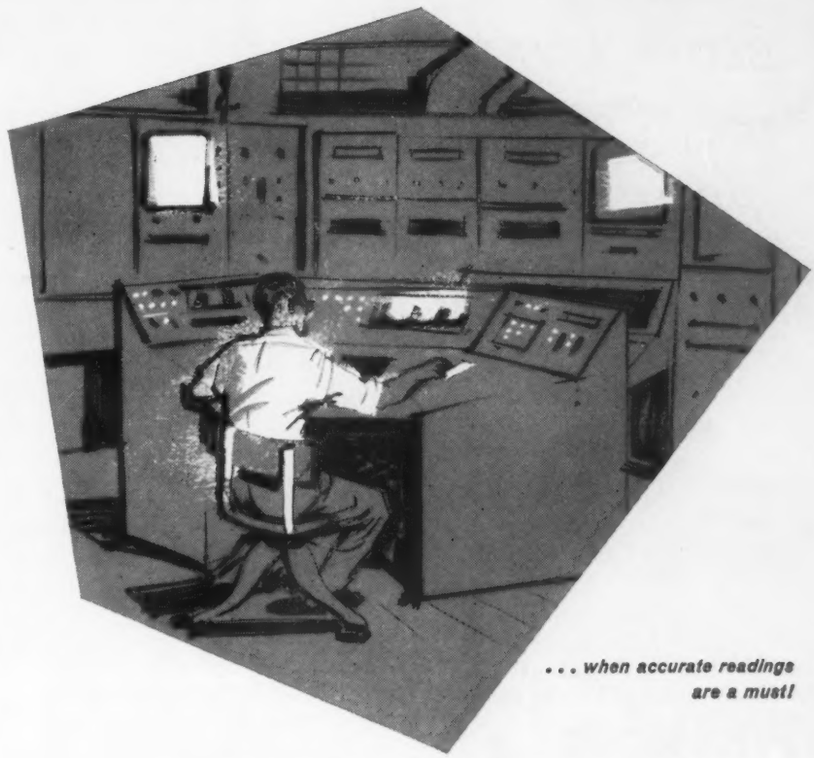
STUD-TYPE TERMINAL BLOCKS 239

Stud-type molded-barrier terminal blocks available in various sizes accommodating from 1 to 26 stud posts, and in current-handling ratings from milliamperes to 90 amperes for commercial use, and in CFG, MFE, MAI-60, MME and MDG to meet military MIL-M-14 specs. Kulka Electric Corp., Mt. Vernon, New York.

INSTRUMENT CHOPPER 255

Instrument chopper catalog incorporates glossary of chopper terms, component specifications, technical description of chopper test and evaluation equipment as well as details on new miniature OPDT and SPDT choppers. James Vibrapowr Co., Chicago, Illinois.

BORG MICRODIALS...



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Borg Microdials provide fast, accurate dial readings at a glance. The inline digital presentation of these dials permits maximum reading speed even under forced fast reading conditions. Settings are made just as easy . . . just as quick. Finger-tip brake locks settings in place. Available in three-digit ten-turn, four-digit hundred-turn and five-digit thousand-turn models. Also available are concentric scale dials for devices of ten turns or less. Get the complete Microdial story from Borg today.

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AMPHENOL-BORG ELECTRONICS CORPORATION
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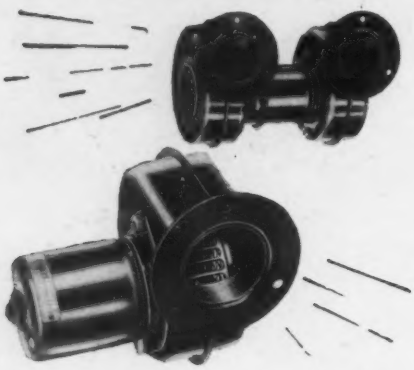
CIRCLE 52 ON INQUIRY CARD

put HEINZE in your designs

BLOW AWAY HOT PROBLEMS



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VERNIER VARIABLE RESISTOR 259

Designed for fine tuning applications, Vernier carbon variable resistor has 12-½ to 1 ratio and is 15/16 inches in diameter. Chicago Telephone Supply Co., Chicago, Ill.

RECORDING AND MEASURING INSTRUMENTS 160

16 page catalog describes entire line of dynamic-measuring and recording instruments including oscillographs, data amplifiers and bridge balances; vibration measuring equipment; and power supplies. A summary of specifications for CEC standard galvanometers is also included. Consolidated Electrodynamics Corp., Pasadena, Calif.

GYROS 242

Two brochures on floated free gyros and on rate gyros present typical gyro designs, major design features, and application advantages and specifications. Daystrom Pacific, Los Angeles, Cal.

DISC THERMOSTATS 176

Bimetal disc thermostats for use in electronic, avionic and missile applications requiring narrow differentials and close temperature control. Stevens Manufacturing Co., Mansfield, Ohio.

BIMETAL THERMOSTATS 248

19 types of bimetal thermostats for use in appliances, apparatus, electronic and avionic applications are described in bulletin. Stevens Mfg. Co., Mansfield, Ohio.

FAR-INFRARED HEATERS 182

Heaters, using the far-infrared wavelength, useful for the drying, curing and baking of plastic textiles, paper and inks, ceramic products and for metal and glass work with ratings ranging from 375 watts and lengths from 12¾ inches. Edwin L. Wiegand Co., Pittsburgh, Pa.

IRON BEARINGS 241

More economical than bronze bearings, new self-lubricating iron Oilite 212 bearings, suitable for many "bronze" applications, are described with complete performance data, properties, recommended uses and other "how to use information." Amplex Div., Chrysler, Detroit, Mich.

MINIATURE PLASTIC SWITCHES 178

Ten models, with actuating button in center position cover an operating force range of 3 to 20 ounces; 9 models with actuating button in off-center position operate in range of 2.5 to 60 grams. Both series meet MIL specs. Haydon Switch, Inc., Waterbury, Conn.

RECTANGULAR CONNECTORS 163

Specs of miniature rectangular connectors describe several closed ring contact arrangements for heavy duty power applications. DeJur-Amsco Corp., Long Island City, New York.

ELECTRO-SHEAVE BROCHURE 243

New electro-sheave brochure describes in detail new clutch-pulley package for direct installation on standard electric motors from 1 to 25 hp. Warner Electric Brake & Clutch Co., Beloit, Wisc.

SUBCARRIER OSCILLATOR CALIBRATOR 151

For instrument laboratory and field calibration of the subcarrier oscillators used in FM telemetering and is also adaptable to high speed automatic checkout systems. Wayne D. Patterson, Inc., L. A., Cal.

HEAT EXCHANGER 120

19 page catalog explains where integral finned tubes should be used, how fins affect the design of heat exchangers and fouling factors, and a comparison of finned and bare tube exchanger costs. Wolverine Tube, Allen Park, Mich.

CARRIER AMPLIFIER 133

Bulletin describes system features double integration function with sections on controls and indicators, physical description, and specifications. Consolidated Electrodynamics Corporation, Pasadena, California.

MINE SAFETY DEVICE 135

Data includes schematic diagram and detailed explanation, general electrical specifications for use in protection against ground faults and short circuits on D. C. operated off-track mining machines and their trailing cables. Joy Manufacturing Co., St. Louis, Mo.

PLASTICS 161

Catalog, price list, specs., and table of properties of various plastics—plexiglas, cadco, teflon, nylon, vinylite, acetate, butyrate, styrene, polyethylene, mylar, kel-f, fiberglass, phenolic and implex—are presented in quick reference form. Cadillac Plastic and Chemical Co., Detroit, Mich.

FORCE BALANCE PRESSURE TRANSDUCERS 149

Brochure describes three basic force balance pressure transducers. Designed for use static pressure, pressure ratio, and pressure difference in very intricate air data computers. Transmission of computed quantities by means of electrical servo loops permits remote indication and tie-in with navigational computers, auto-pilots, and other systems for aircraft and missile control. M. Ten Bosch, Inc., Pleasantville, N. Y.

GROUND SUPPORT EQUIPMENT 129

GSE bulletin for countdown and pre-countdown checkout details, static checkout unit, dynamic checkout unit and Ullage simulation assembly. Consolidated Electrodynamics Corp., Pasadena, Cal.

MECHANICALLY HELD AUTOMATIC TRANSFER SWITCH 180

Automatic transfer switch, with an arc chute design that provides protection of all main contacts, is available in NEMA size. Zenith Electric Co., Chicago, Ill.

SWITCH ACTUATED BY HOOK 134

2 series of switches designed for use where it is desirable to actuate the switch by hanging an accessory on a hook, such as hanging up a head set or microphone. Silver contacts rated at 3 amps, 120 volts, ac non-inductive load are standard. Switchcraft, Inc., Chicago, Ill.

ELECTRONIC COOLING UNITS 165

Design details and application information on single and dual blower units for electronic cooling applications; units meet MIL specs; various designs for computers, control panels, telemetry cabinets, consoles, and special designs for custom applications. McLean Engineering Labs, Princeton, N. J.

A-C SNAP SWITCHES 168

Four page bulletin details advantages, designs and applications of these switches. Circle F Mfg. Co., Trenton, N. J.

ROTARY SWITCHES 224

Complete specifications and design information on 4 separate types of multiple rotary switches are detailed with cross reference to applicable BuShips drawing no. Couch Ordnance, Inc., N. Quincy, Mass.

TIMING DEVICES 206

Brochure gives specs and diagrams of mechanical timers, time switches and time delayed relays developed for military and industrial use. M. H. Rhodes, Inc., Hartford, Conn.

MAGNETIC DISC BRAKES 204

Bulletin describes direct-acting magnetic disc brakes and gives formulas based on torque and thermal capacity. Dings Brakes, Inc., Milwaukee, Wisconsin.

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This unit is available as a single pole, 10 position switch and can be obtained with up to four poles on a single deck.

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Contact Rating: 1 ampere, 250V D. C. into resistive load. 350 MA, 100V D. C. into inductive load.

Insulation Resistance: 200,000 megohms between any two terminals or between any terminal and shell. Measured at 25° C., 50% RH, at sea level.

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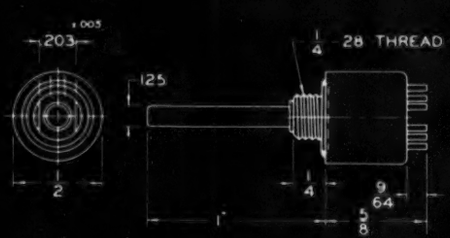

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	—3,000 to +80,000 ft or .4 to 50 psia	Actuation Setting Range of Tested Available Models	**Mach .75 to Mach 3.00**	
	SPDT 18-30 VDC, 2.5A Ind.	Electrical Rating	**SPDT 28 VDC, 2.5A Ind.**	
	—65 to 160F —65 to 275F —65 to 400F	Temperature Ratings Available	**—65 to 212F**	
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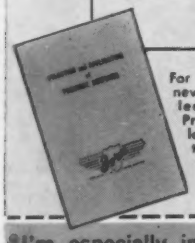

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a masculine phase succeeding upon a feminine one.

Strictly speaking, I have investigated this first phase only, that which comes easily and without effort as a spontaneous expression of an integrated person or of a transient unifying within the person. It can come only if a person's depths are available to him, only if he is not afraid of his primary thought processes.

I shall call "primary creativity" that which proceeds from and uses the primary process much more than the secondary processes. The creativity which is based mostly on the secondary thought processes, I shall call "secondary" creativity. This latter type includes a large proportion of production-in-the-world, the bridges, the houses, the new automobiles, even many scientific experiments and much literary work which are essentially the consolidation and exploitation of other people's ideas. It parallels the difference between the commando and the military police behind the lines, the pioneer and the settler. That creativity which uses *both* types of process easily and well in good fusion or in good succession, I shall call "integrated creativity." It is from this kind that comes the great work of art or philosophy or science.

CONCLUSION

The upshot of all of these developments can, I think, be summarized as an increased stress on the role of integration (or self-consistency, unity, wholeness) in the theory of creativenes. Resolving a dichotomy into a higher, more inclusive unity amounts to healing a split in the person and making him more unified. Since the splits I have been talking about are within the person, they amount to a kind of civil war, a setting of one part of the person against another part. In any case, so far as creativeness SA is concerned, it seems to come more immediately from fusion ot primary and secondary processes rather than from working through the repressive control of forbidden impulses and wishes. It is, of course, probable that defenses arising from fear of these forbidden impulses also push down primary processes a kind of total undiscriminating, panicky war on *all* the depths, But it seems that such lack of discrimination is not, in principle, necessary.

To summarize, creativeness SA stresses first the personality rather than its achievements, considering these achievements to be epiphenomena emitted by the personality and therefore secondary to it. It stresses characterological qualites like boldness, courage, freedom, spontaneity, perspicuity, integration, self-acceptance, which make possible the kind of generalized creativeness I've been talking about, which, in turn, expresses itself in the creative life or the creative attitude or the creative person. I have also stressed the expressive or "Being" quality of creativeness SA rather than its problem-solving or product-making quality. Creativeness SA is "emitted" like radioactivity and hits all of life, regardless of problems, just as a cheerful person "emits" cheerfulness without purpose or design or even consciousness. It is emitted like sunshine; it spreads all over the place; it makes some things grow (which are growable) and is wasted on rocks and other ungrowable things.

As I come to the end I am quite aware that I have been trying to break up widely accepted concepts of creativity without being able to offer in exchange a nice, clearly defined, clean-cut substitute concept. Creativeness SA is hard to define because sometimes it seems to be synonymous with health itself, as Moustakas has suggested in **The Self** (Harpers 1956). And since self-actualization or health must ultimately be defined as the coming to pass of the fullest humanness, or as the "Being" of the person, it is as if creativity SA were almost synonymous with, or a sine qua non aspect of, or a defining characteristic of, essential humanness. *END*

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Synchronous Motor

12 page bulletin describes a new enclosed permanent magnet type of synchronous motor for application in servo mechanisms, automatic machines, remote control and numerical control systems. At 60 cycles speed remains accurately at 72 rpm without gear reduction; torque is 150 oz-in. Because the motor has 3 leads only, a single-dash pole, 3-position switch gives instant starting, stopping and reversing. When used as a stepping or inching motor, d-c impulses are converted into either 200 or 400 precise increments of one revolution of the motor shaft.

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Combined Plug-Socket

A new universal electric connector, a combined plug-or-socket unit handles up to 26 circuits and eliminates the need for matching male with female connectors in communications and other equipment. A $1,200,000 Defense Department contract for the device has been received, and production is under way, said Mr. H. R. Cammer, president of Specialty Electronics Development Corporation, pointing out that the connector, first of its kind to be made in the U. S., "has a number of valuable commercial applications in telephone, telegraph and other electrical circuits". The new type connector, a "non-reversing hermaphrodite", acts as both plug and socket at either end of a multi-circuit telephone or telegraph cable, and is highly important for military purposes in making rapid connections under mobile field conditions. Any connector can be plugged directly into another without regard to polarity or change in conductor path. The unit being made under the current defense contract, Mr. Cammer said, is designed to connect up to 26 circuits in a telephone cable. The basic principle, however, can be used for a single power or communications circuit, or an even larger number of cable circuits if required. "Eliminating the need for adapters or junction boxes in any type of electrical hook-up, either for power communications, the new connector eliminates the potential error of mismatching cable ends, or the possible need for soldering new connections. It also provides substantial operating economics since there is no need to carry inventories of adapters and junction boxes." Specially designed for the rugged field conditions, the unit is only 2½ inches in diameter and 7 inches long. Of completely waterproof construction, it has a unique arrangement of pins for maximum insulation of each circuit. All electrical contacts are gold-plated to prevent corrosion and loss of conductivity.

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